MENORCA 2030 STRATEGY

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ROADMAP FOR DECARBONISING THE ISLAND'S ENERGY SYSTEM

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The **Menorca 2030 Strategy** is the result of the collective efforts of endless organisations, institutions, companies and individuals who, from their different areas of expertise, have made a commitment to prioritising what was already a social and political consensus; the energy transition of the island of Menorca.
After several months of intensive efforts, on the 15th of April 2019, the Plenary Session of the Island Council of Menorca approved the Strategy, which details the roadmap that Menorcan society shall undertake to propel the decarbonisation of the island's energy system.

Menorca hence joined the efforts that the European and international scene are already carrying out to mitigate the effects of climate change, which materialise, given the territory's characteristics, in the European Commission's "Clean Energy for EU Islands" initiative, of which Menorca is an active member since February of 2019.
Many initiatives set forth in this Strategy have already been set in motion, while others will commence in the near future so as to comply with the ambitious goals that have been established.

We would like to express our most sincere gratitude to all those individuals who, through their involvement, effort and enthusiasm, have helped make the Menorca 2030 Strategy a reality. Specifically, we would like to thank the steering committee, who at their meeting on the 5th of July 2018 set off on the voyage that would culminate in this document.

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1

Menorca 2030 Strategy

1.1. A ROADMAP FOR ENERGY TRANSITION

The Menorca 2030 Strategy serves as the roadmap for decarbonising the island of Menorca's energy system, moving from its current configuration to a model based on renewables. Its frame of reference includes the EU Roadmap 2050 decarbonisation plan, the Law on Climate Change and Energy Transition in the Balearic Islands and the principles of its very distinction as a Biosphere Reserve.

The drafting of a roadmap for the decarbonisation of Menorca's energy system is based on a comprehensive vision of the different energy sources, infrastructures and uses, in hopes of drastically reducing greenhouse gas emissions (GHG). The proposal traces the path to redirect the energy system from its current configuration toward a model based on renewables, fully compatible with the commitments taken on by the nations of the EU for 2030 and, essentially, with the principles of a Biosphere Reserve.

The Menorca 2030 Strategy has the ultimate goal of placing Menorca at the forefront of clean energy usage and serving as a benchmark for other territories of the European Union. It defines the island of Menorca's energy transition to establish priorities of energy policy, actions to be carried out, the formation of channels of cooperation, support and financing, as well as the creation of a guide for decision-making in public and private sectors. With this strategic document, Menorca intends to be part of the measures of the European Commission's "Clean Energy for EU Islands" initiative, while also facilitating other public and private initiatives that contribute to strengthening the island's energy transition.

The frameworks of reference for decarbonisation are the EU Roadmap 2050 and Law 10/2019, of the 22nd of February, regarding Climate Change and Energy Transition, approved by the Balearic Island Parliament, which establish the goal of a reduction in greenhouse gas emissions of at least 40% for 2030, in comparison with 1990 levels.

This roadmap is based on the process initiated in 2016 with the creation of the Strategic Directives of Menorca (DEM), and the stimulus the Island Council of Menorca (CIMe) aims to provide for change in the island's energy model. Within the DEM process, a detailed diagnostic of the current energy system has been developed, which serves as a basis for this roadmap.[1] Another solid information base is the set of indicators that the Socio-Environmental Observatory of Menorca (OBSAM) has published over the last 20 years regarding the dynamics followed by the Biosphere Reserve. OBSAM and DEM are projects of the Menorcan Institute of Studies (IME), a government agency affiliated with the CIMe.

Also to this end, interest and support are received from the remainder of those public administrations involved, both on a national level (Ministry of Ecological Transition and Demographic Challenge), regional (Balearic Island Government), and local (City Halls of Menorca and the Waste and Energy Consortium of Menorca), as well as a broad representation from the private sector, which has played an active role in the development of this roadmap. Additionally, the Social Council and the Scientific Council of the Biosphere Reserve and the Economic and Social Council of Menorca (CES) are forums for public participation in which the strategy's creation process has been closely monitored.

[1] ***The document is available in Spanish, Catalan and English through the following link:*** **http://www.ime.cat/contingut.aspx?idpub=14611**

1.2. WHY MENORCA FOR A ZERO EMISSIONS STRATEGY?

The advance of climate change caused by greenhouse gas emissions (GHG) of anthropogenic origins has placed the urgent need for commitment to the reduction of emissions for their mitigation at the heart of international agendas.

The island of Menorca, declared in 1993 as a Biosphere Reserve by UNESCO, wishes to be part of this global alliance for the mitigation of climate change. In such, Menorca presents many highly appropriate characteristics for the implementation of a strategy for energy transition.

Biosphere Reserve

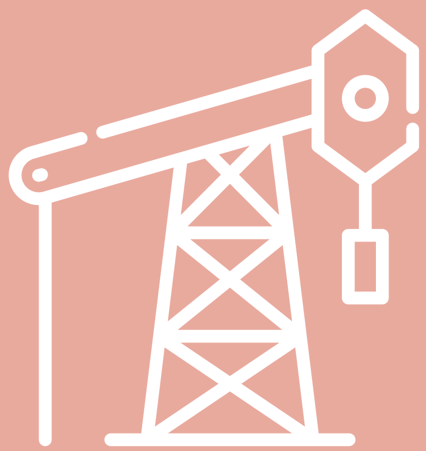
Menorca and its adjacent waters make up a Biosphere Reserve that covers 514,485 ha of recognised surface area. The island is home to a privileged natural environment and a high level of territorial and landscape protection. The installation of infrastructures for renewable energies within the context of this territorial conservation fits perfectly into the challenge as a Biosphere Reserve of harmonising human activity and environmental preservation.

Social and political commitment

There exists a high degree of social and political consensus regarding the need for a new energy model based on renewables generated on the island itself,[2] which is clearly reflected in the support that this document has received.[3] Additionally, the Menorca Biosphere Reserve Action Plan (2018-2025) and the revision of the Insular Territorial Plan of Menorca (in process) as the principal planning instruments on an island level, consider energy transition to be one of their priority concepts.

[2] *Recent events, like the island's electrical disconnection from the Balearic electric power system (November, 2017) or the electrical power outage that affected half of the island for over 48 hours (October 2018), have increased the level of social concern and urgent demand to reshape the electric power system. In addition to this demand, there is also deficient air quality in areas around the island's thermal power plant, as well as the resulting public health complications.*

[3] *See Annex A.*



Dependence on outside energy

Virtually all of Menorca's electricity demand comes from the burning of fuel oil and diesel oil, and the contribution of renewable energy reaches only 1% of all primary energy. The total energy dependence on fossil fuels, together with the recent episode of Menorca's disconnection from the Mallorca-Menorca electric power system, clearly demonstrate the system's vulnerability and the need for a model that is not dependent on outside energy sources.

Emissions and impact

In addition to the high level of greenhouse gas emissions associated with the energy system, we must also consider growing concerns regarding health risks from the polluting emissions of the island's principal electricity production plant, which makes a strategy for decarbonisation based on gradual increases in electrical energy from renewable energy sources a positive impact both on the environment and on the health of the island's population.

Initial assessment

Comprehensive analysis of the island's energy system, carried out via the Strategic Directives of Menorca (DEM), allows for a comprehensive understanding of the baseline upon which the strategies of this roadmap are defined. Also existent is a cohesive set of energy indicators, developed over many years by the Socio-Environmental Observatory of Menorca (OBSAM), which facilitates the monitoring of those established objectives.

Living lab

Its size (702 km^2, 100,000 inhabitants and 8 municipalities), location at the centre of the Western Mediterranean, and elevated tourist affluence, make Menorca an ideal laboratory for the integration of renewable energies, alternative means of transport, efficiency in construction and new economic sectors. Furthermore, as a member of the World Network of Island and Coastal Biosphere Reserves, Menorca could become a highly replicable experiment.

1.3. PRINCIPLES AND CRITERIA OF THE MENORCA 2030 STRATEGY

The Menorca 2030 Strategy is contemplated from an insular context and within the principles that must be in effect for a Biosphere Reserve: to secure and improve supply, reduce outside energy dependence, promote the local economy and ensure the preservation of the environment through criteria of sustainability.

Supply security

The design of the future energy system must maintain and improve upon current levels of quality, reliability and supply security, while reducing outside energy dependence in favour of self-sufficient initiatives, which must also include the replacement of non-renewable fossil fuel deposits with renewable energy flows.

Social involvement

Energy transition requires the community's participation as both a driving force and as a beneficiary of the change in the energy model. This must take place by fostering public involvement in the implementation of initiatives as well as in the investment needed for the energy transition plan.

Economic viability

Energy transition must also ensure the economic sustainability of the new energy model, whose imperative central concepts include the creation of local industry associated with clean energies, attracting professionals in areas of expertise related to renewables, efficient management, the modernisation of grids and the stimulation of the local economy.

Environmental sustainability

The island's energy transition model is based on an approach of commitment to the execution of actions that mitigate climate change and improve air quality. This strategy for decarbonisation thus includes, as part of its main objectives, a more than 50% reduction in greenhouse gas emissions.

Landscape integration

The Menorca 2030 Strategy takes into account the integration of the infrastructures associated with energy transition within Menorca's ecosystems and landscape, preserving the values of the island's agro-forest mosaic and historical heritage.

1.4. OBJECTIVES: TOWARD A DECARBONISED ENERGY SYSTEM

The Menorca 2030 Strategy establishes an overall objective; the reduction of greenhouse gas emissions, taking as a frame of reference the EU Roadmap strategy and other specific objectives for its achievement, like the implementation of renewables and the reduction of fossil fuel consumption.

General objective: 50% less CO_2 emissions for 2030. The Menorca 2030 roadmap for decarbonisation of the island establishes the goal of reducing pollutant emissions by at least 50% with respect to those of 1990. The frame of reference taken by the proposal is the EU Roadmap 2050 strategy, as it is the most ambitious with regard to decarbonisation, as depicted in figure 1.

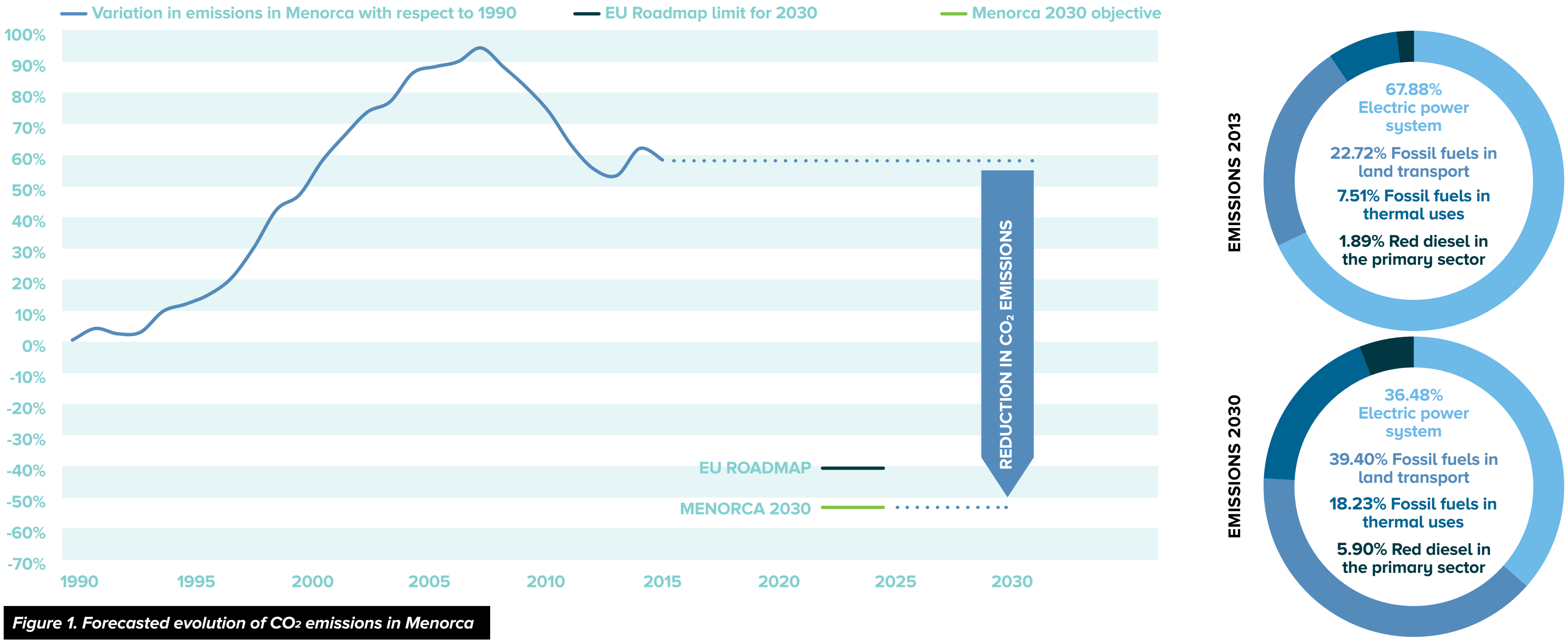
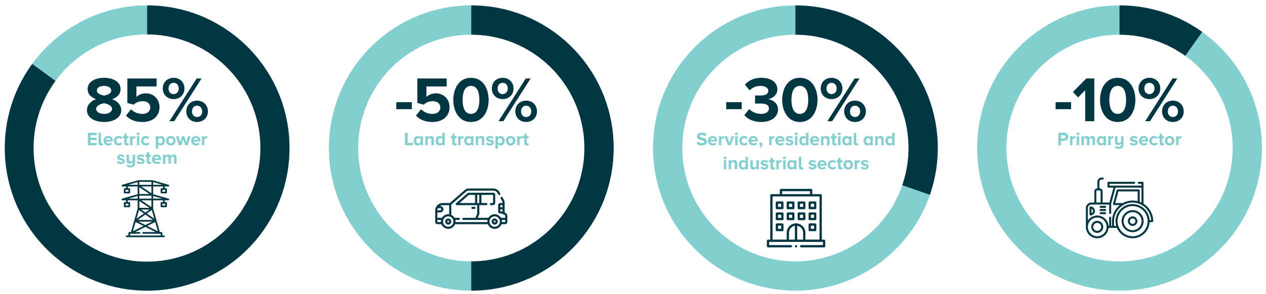


Figure 1. Forecasted evolution of CO_2 emissions in Menorca

Specific objectives: reduction in consumption and introduction of renewables to substitute fossil fuels. To achieve the overall objective of emissions reductions for 2030 set forth by the strategy, a set of specific goals has been established regarding the primary energy uses on the island.



Coverage of electricity demand through renewables

- 261 MW from photovoltaic power plants
- 16.5 MW from wind farms
- 4 MW from wave power
- 400 MWh of electrical storage
- Smart grids
- Dual electrical power link with Mallorca
- Thermal power plant as backup and emergency power with natural gas or hydrogen

Reduction in fossil fuel consumption in land transport with respect to 2013

- Vehicle/ride sharing
- Electrification of transport
- Collective transport
- Alternatives to private motorised vehicles

Reduction in fossil fuel consumption for thermal uses with respect to 2013

- Energy efficiency and renovation
- Demand management
- Electrification
- 30 MW of renewable self-consumption in urban areas
- Advanced markets
- Biomass

Reduction of red diesel consumption in the primary sector with respect to 2013

- Energy efficiency
- Renovation of machinery

Figure 2. Menorca 2030 specific objectives.

EVOLUTION OF THE SPECIFIC OBJECTIVES: 2020, 2025, 2030

For the year 2020, the Menorca 2030 Strategy estimates that the implementation of renewables will cover 18% of electricity demand; for 2025, 54%, and for 2030, 85%. This transition toward use of clean energies will mean that for 2030, half of all final energy consumption will originate from renewables, having thus significantly reduced the production of energy from fossil fuels.

Projections regarding the progressive achievement of the strategy's specific objectives shall set 2016 as the reference year, as the most recent year in the data set that includes all information available regarding the island's energy demand corresponding to the different energy carriers used for the study.
Figure 3 details the forecast predicted for coverage of electricity demand with renewables and the reduction in fossil fuel consumption in the various scopes of action until 2030.

With regard to the evolution of final energy demand, and according to the specific objectives set forth, predictions for the Menorca 2030 Strategy foresee that 50% of final energy demand for Menorca in 2030 will be electrical energy of renewable origins. Figure 4 shows the evolution of such demand expressed in GWh for the period 2016-2030 and its renewable or non-renewable source.

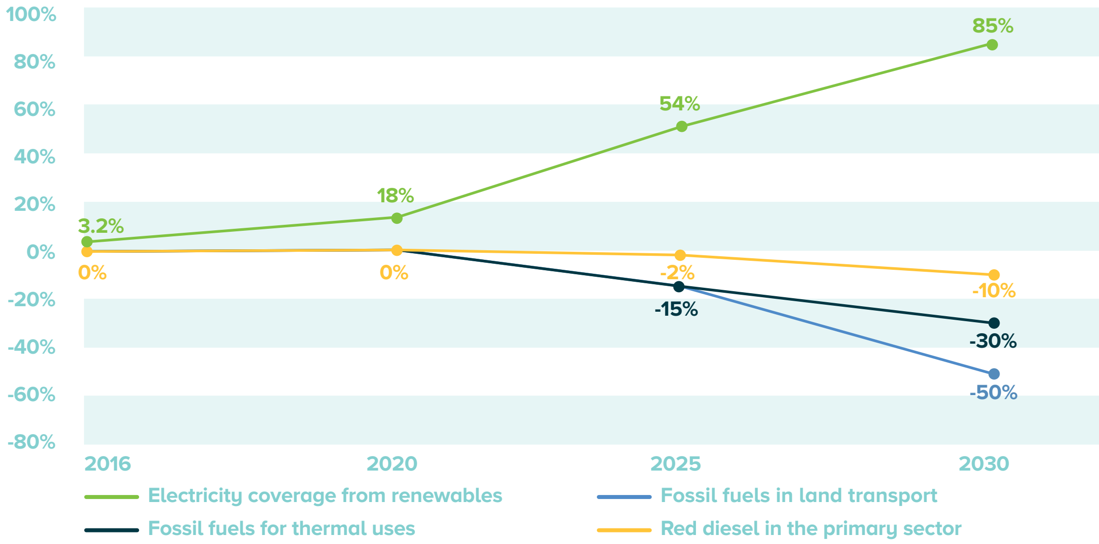


Figure 3. Evolution of specific objectives.

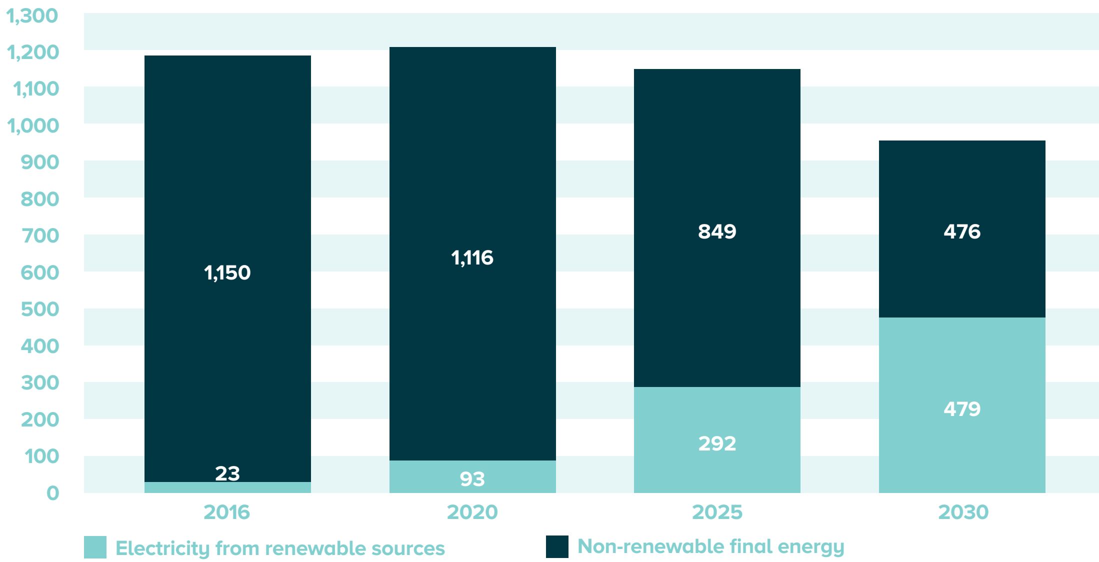
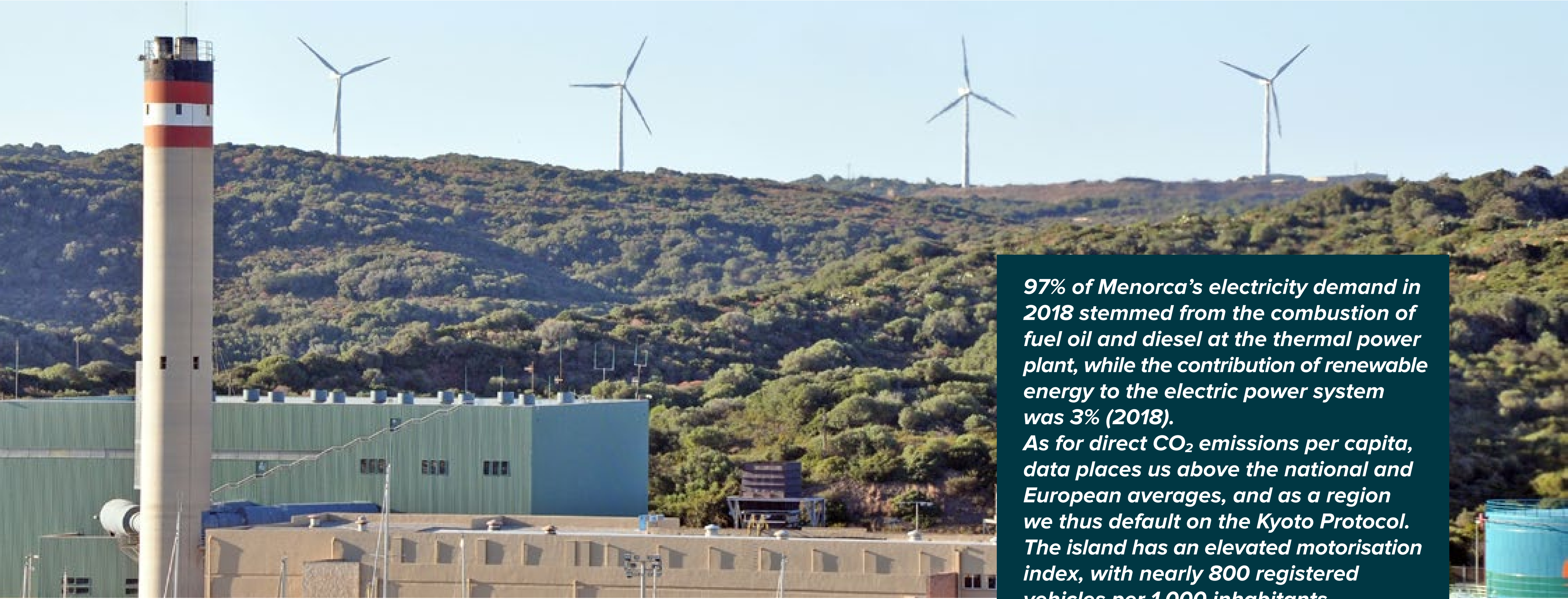


Figure 4. Forecasted evolution of final energy demand. Units: GWh.

1.5. ASSESSMENT OF THE INITIAL SITUATION



97% of Menorca's electricity demand in 2018 stemmed from the combustion of fuel oil and diesel at the thermal power plant, while the contribution of renewable energy to the electric power system was 3% (2018).
As for direct CO_2 emissions per capita, data places us above the national and European averages, and as a region we thus default on the Kyoto Protocol.
The island has an elevated motorisation index, with nearly 800 registered vehicles per 1,000 inhabitants.

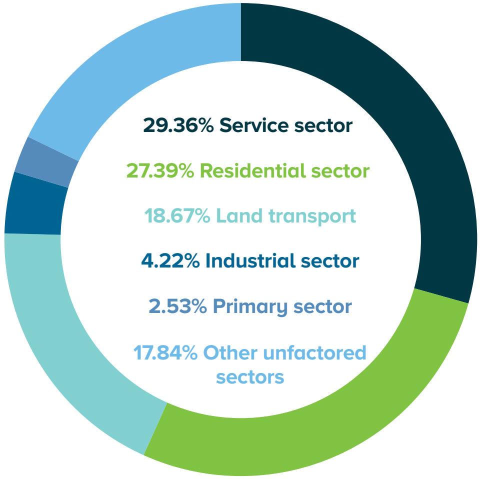


***Figure 5.** CO_2 emissions by sector.*
Source: Strategic Directives of Menorca (DEM), IME.

***Figure 6.** Comparative of annual CO_2 emissions per capita.*
Units: tCO_2 per capita. Source: Strategic Directives of Menorca (DEM), IME.

Menorca's baseline, before the implementation of this decarbonisation strategy, is one of a territory with an elevated fossil fuel energy dependence, which also entails high values of pollutant and greenhouse gas emissions (GHG).

Figure 5 depicts the weight of the greenhouse gas emissions from the sectors considered most pollutant and the object of this roadmap. Foreseen actions shall cover over 80% of the direct GHG emissions.

With regard to direct CO_2 emissions per capita, Menorca sits above the national and European averages, and is, as a region, noncompliant with the different international agreements for reductions in emissions since Kyoto.[4]

The electric power system has an installed power capacity of 5.1 photovoltaic and 3.2 wind, which makes up a current contribution (2018) to the electricity mix of 3%. The remaining 97% of the electricity demand is covered by the thermal power plant through combustion of fuel oil and diesel with an efficiency of 33%.

As for the transport sector, land transport makes up 30% of Menorca's final energy consumption. The island has an extremely high motorisation rate, with nearly 800 registered vehicles per 1,000 inhabitants (registered population). 53% of all journeys are made in private vehicles; 42% on foot, 4% by bicycle, and just 1% on public transportation. There are nearly 50,000 registered passenger automobiles and 9,200 motorcycles. This data does not include much of the rental fleet, as it is not registered on the island.

SANKEY DIAGRAM, CURRENT ENERGY SITUATION

The Sankey diagram on the following page shows the weight of the different sources of primary energy, the end use of the different sectors and the losses from Menorca's energy system.

[4] *See document:* http://www.obsam.cat/indicadors/sectors-economics/energia/emissions-CO2/Emissions-directes-CO2-1990-2016.pdf

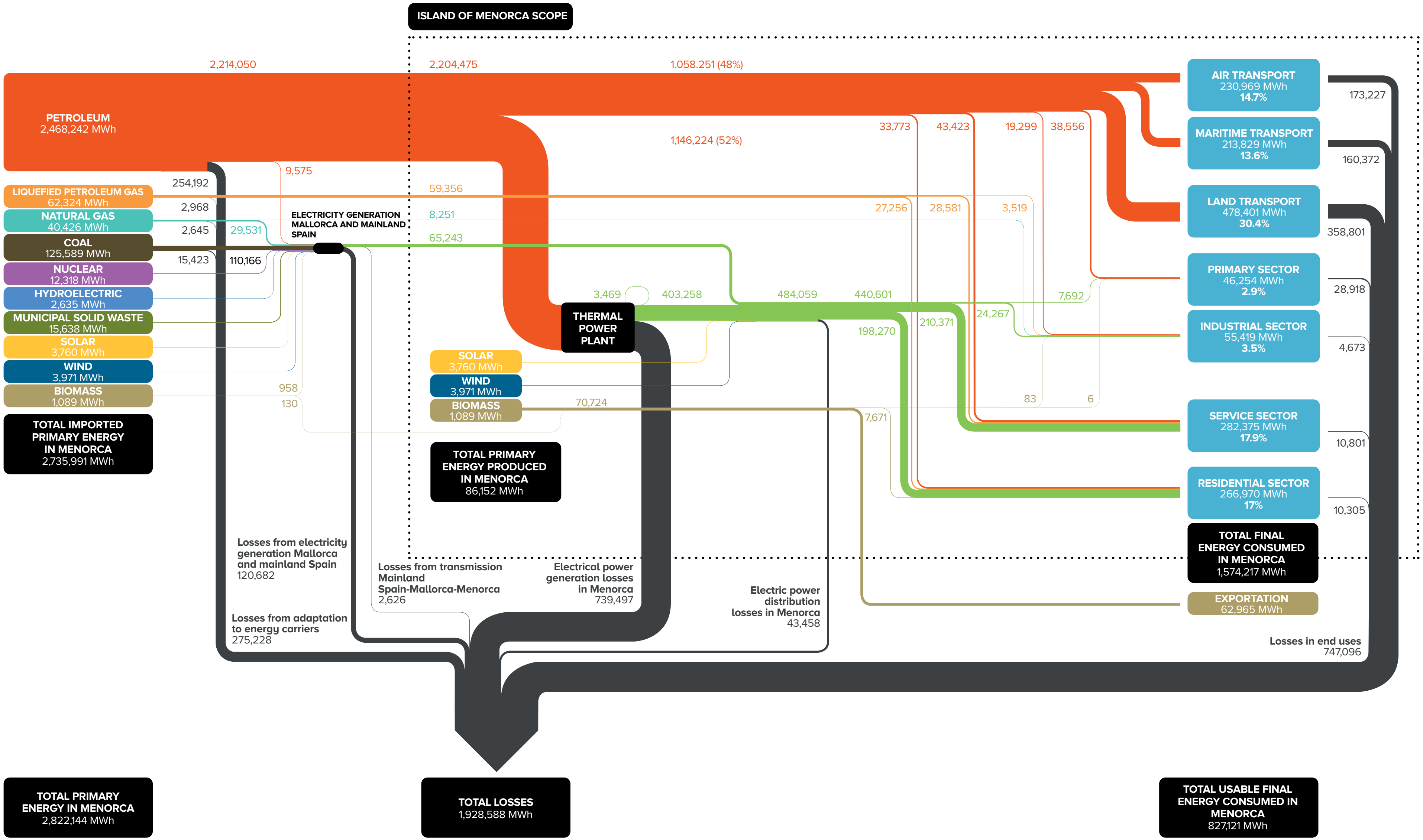


Figure 7. Sankey diagram of the current energy situation in Menorca. Source: Strategic Directives of Menorca (DEM), IME.

2

Actions of the Menorca 2030 Strategy: an island with renewables, reduced consumption and greater efficiency

The roadmap for the decarbonisation of Menorca proposes compliance with the objectives set forth through actions focused on the island's strategic sectors. For each area of action, a series of measures has been designed according to its specific characteristics. Each of these is based on the introduction of renewables, a reduction in energy consumption and improved energy efficiency. These actions take into account the context, resources and technologies that are currently available and viable, although with built-in flexibility for the eventual incorporation of emerging technologies.

The principal areas of action of the Menorca 2030 Strategy include: the electric power system, which projects for a high level of penetration of self-supplied renewables; land mobility, which proposes the introduction of electric vehicles (EVs) and the promotion of shared and collective transport; the residential sector, with individual and shared self-consumption and energy renovation as the principal measures; and the service sector, which includes among others, tourism and public administration. The primary actions for this last sphere prioritise increased self-consumption, improved efficiency and better management of energy demand.

[5] Excluded from the proposed objectives and actions are air and maritime transport, as these are regulated by national and international authorities, making measures taken through local policy for said sectors currently quite difficult. Although their emissions are relatively low when considering the island's total attributable emissions, future planning may nevertheless consider measures of compensation regarding the carbon footprint of these sectors.

2.1. AN ELECTRIC POWER SYSTEM BASED ON RENEWABLES

The scenario proposed for the island's electric power system for 2030 implies coverage of 85% of total electrical energy demand through renewable sources. The achievement of this goal takes into account the implementation of land-based photovoltaic energy in urban areas, wind and wave energy, and electrical storage with batteries or other technologies.

The starting point, or annual electrical energy demand for 2020, is 513 GWh, which will show increasing trends, in proportion with electrification of demand, until reaching 561 GWh/year, as indicated in figure 8.

To achieve this objective, various scenarios of renewable energy penetration are considered based on the different technologies, such that they will help achieve the goal of 85% in 2030, with the following scenario believed to be the most viable:

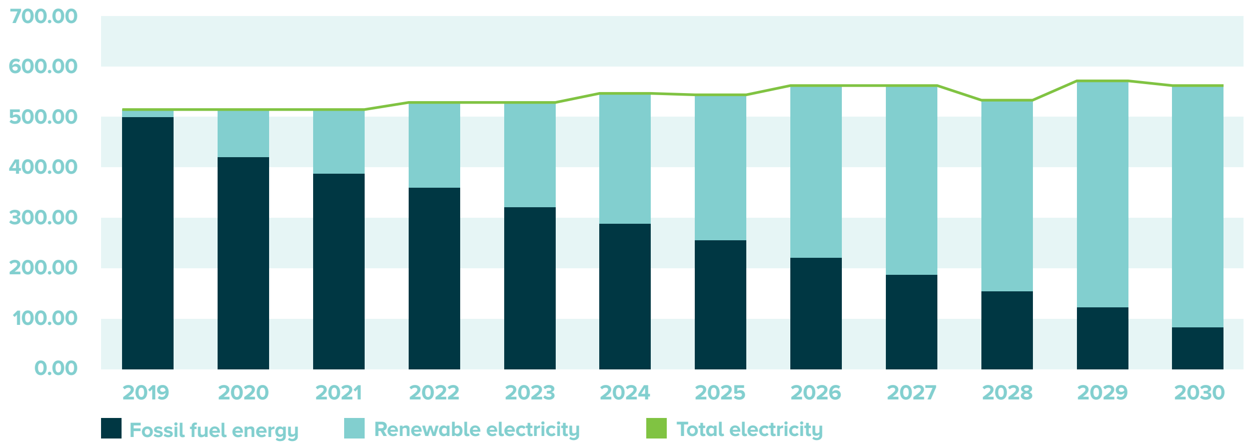


Figure 8. Evolution of electrical energy demand and its coverage for the period 2019-2030. Units: GWh.

261 MW
OF PHOTOVOLTAIC ENERGY IN LAND-BASED GENERATION PLANTS

16.5 MW
OF WIND POWER

30 MW
OF PHOTOVOLTAIC AND MICRO-WIND POWER WITH SELF-SUPPLY IN URBAN AREAS

4 MW
OF WAVE ENERGY IN THE PORT OF CIUTADELLA

400 MWh
OF ELECTRICITY STORAGE VIA BATTERIES OR OTHER TECHNOLOGIES

2.1.1. Land-based photovoltaic

Over the course of the 2020-2030 period, the implementation of 190 MWp of land-based photovoltaic power must be foreseen. This will prioritise the utilisation of sites in developed areas, always with the least environmental and landscape impact possible, maximising the use of existing infrastructures, and allowing for the involvement of the local community. All this will require the installation of between 2 and 3.5 MWp and the authorisation and execution of over 20 MWp/year over the aforementioned period.

Land-based photovoltaic energy in Menorca sets off from an installed power level of 5.1 MWp, to which 65.9 MWp must be added through projects under evaluation that already have administrative authorisation, pending only their material execution. Therefore, over the course of the 2020-2030 period, the installation of 190 MWp of land-based photovoltaic power must be planned and executed, while also being conveniently integrated into the island territory's physical reality.

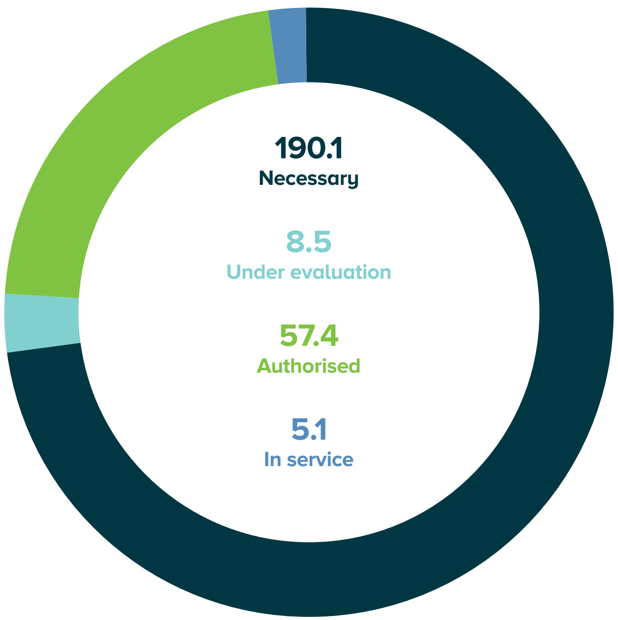


Figure 9. Planning for the evolution of land-based photovoltaic installations 2020-2030. Units: MWp.
Source: Prepared by the authors based on data from the Balearic Island Government Department of Energy.

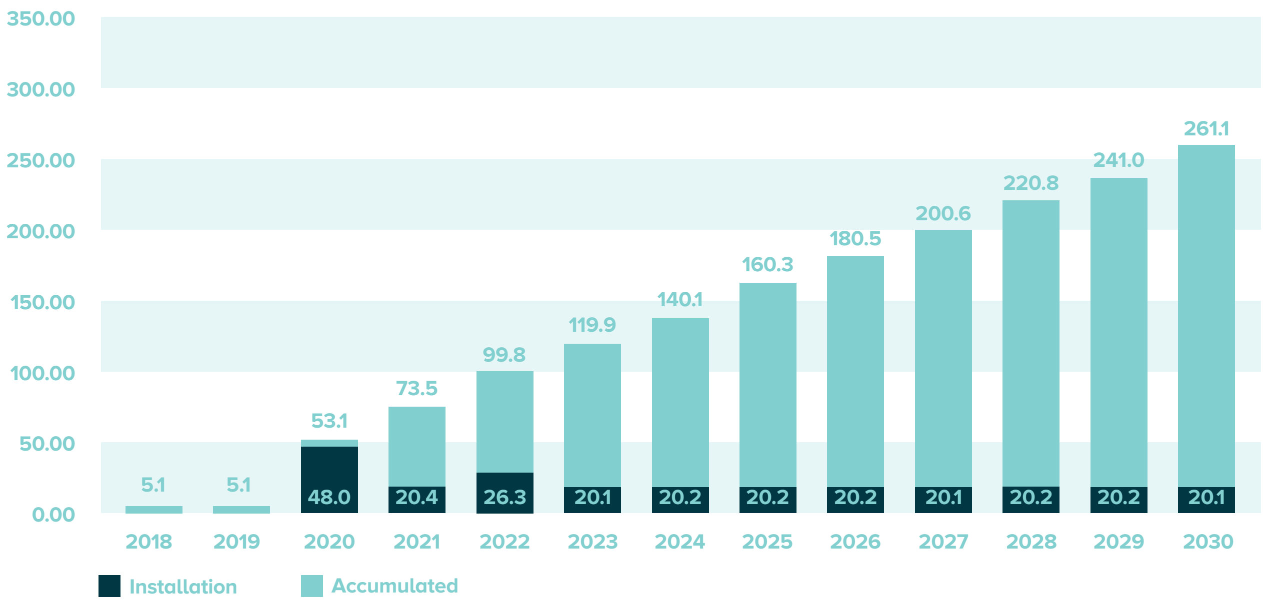


Figure 10. Anticipated evolution of the installed photovoltaic power for 2020-2030. Units: MWp.

Drawing from the premise that renewable energy generation must be located as close to sites of consumption as possible so as to take into account resource availability and minimise technical losses from the grid, the utilisation of sites in developed areas shall be prioritised, always with the least environmental and landscape impact possible, maximising the use of existing infrastructures, and allowing for the involvement of the local community.

All this requires the configuration of plants whose size is adapted to the distribution grid's capacity of 15 kV, with the admissible power of the connection nodes as the limiting factor that conditions the power of the plants to values between 2 and 4 MWp, depending on the different areas. Large capacities in the configuration of plants would imply the implementation of electrical substation lines (depending on the case, from 3.5 MWp). Given the economic cost overrun implicit of a dedicated grid, it becomes clear that in this case, the installations would surpass the 10 MWp of generation power to be economically viable. Given their size, visual impact, land occupation and need for grid access, these installations are difficult to integrate into the island's territorial model, and would hence only exist as exceptions. Regardless, when there is a renewable contingency in the distribution grid of 10 MW or more that affects the same point of the transmission grid, acceptability becomes necessary from a perspective of the system operator prior to obtaining access and connection rights.

As part of the island's territorial planning, and due to disturbances in the structure of the electrical transmission grid, the integration of the aforementioned 190 MWp (as a minimum) most be foreseen, in the form of installations of between 2 and 3.5 MWp, which would require a total of between 75 and 120 land-based photovoltaic installations depending on their power. This requires the authorisation and realisation of over 20 MWp/year over the 2020-2030 period.

On an institutional level, through collaboration with various interest groups, the general criteria for this type of installation has already been defined,[6] with the goal of minimising their environmental and landscape impact and facilitating, when the time comes, the restitution of the different areas to their initial values. It is worth noting that, due to height limitations, the implementation of dual-axis solar tracking photovoltaic installations is unlikely.

[6] ***See document:*** <http://www.caib.es/sacmicrofront/archivopub.do?ctrl=MCRST545ZI73122&id=73122>

2.1.2. Onshore wind

In designing the island's new energy mix, wind energy could provide as much as 25% of total demand. A possible scenario would allow for wind penetration of between 10 MW and 30 MW. Menorca holds enormous potential regarding wind resources, although much of its territory is also under protection. One option would therefore involve the installation of small wind farms of no more than 8 MW made up of two wind turbines.

Figure 11. Map of aptitude for wind energy in Menorca, according to the PDSE.

Within the energy transition strategy forecasted for 2030, we should not rule out any type of renewable technology, and still less so that of wind energy, which has already experienced high levels of development and competitiveness. It is thus believed that the island's new energy mix must include a share of wind energy, which in the future could supply as much as 25% of demand, as described below.

The penetration capacity of wind energy in Menorca's electrical subsystem is conditioned by several factors, including the limiting factor of the island's off-peak demand, as well as the existent capacity for energy management that allows for interconnection with Mallorca's electrical subsystem and the availability of storage systems to extract surplus energy and regulate the grid. A scenario that is considered as allowing for wind penetration would see between 10 MW and 30 MW, with 16.5 MW being the scenario of reference. To limit disturbances to the territory, the installation process contemplates small farms of no more than 8 MW, made up of two wind turbines, which would facilitate their integration in areas that still allow for agricultural and livestock uses.

Menorca holds great potential for wind resources, although much of the territory is also under protection. In this respect, a study[7] has been carried out to determine the most suitable potential areas according to the wind atlas of the Institute for Diversification and Saving of Energy (IDAE)[8] and with locations within the areas of wind aptitude as defined by the Energy Sector Master Plan (PDSE) of the Balearic Islands Government[9]. The study resulted in the establishment of 5 priority zones, of the 9 analysed in total, where it would be possible to install wind turbines of between 3.5 MW and 4 MW, as what is most important isto limit the number of turbines and not their power (the visual impact of a 3 MW turbine and that of a 4 MW turbine is virtually identical).

In selecting these zones, aspects of an environmental, visual and accessibility nature were taken into account,

[7] *Master's thesis "Study of Wind Resources for Energy Transition in Menorca". Ignacio García Belenguer, 2018.*
[8] *See document:* <https://www.idae.es/publicaciones/analisis-del-recurso-atlas-eolico-de-espana>
[9] *See document:* <https://www.caib.es/eboibfront/pdf/es/2015/73/919860>

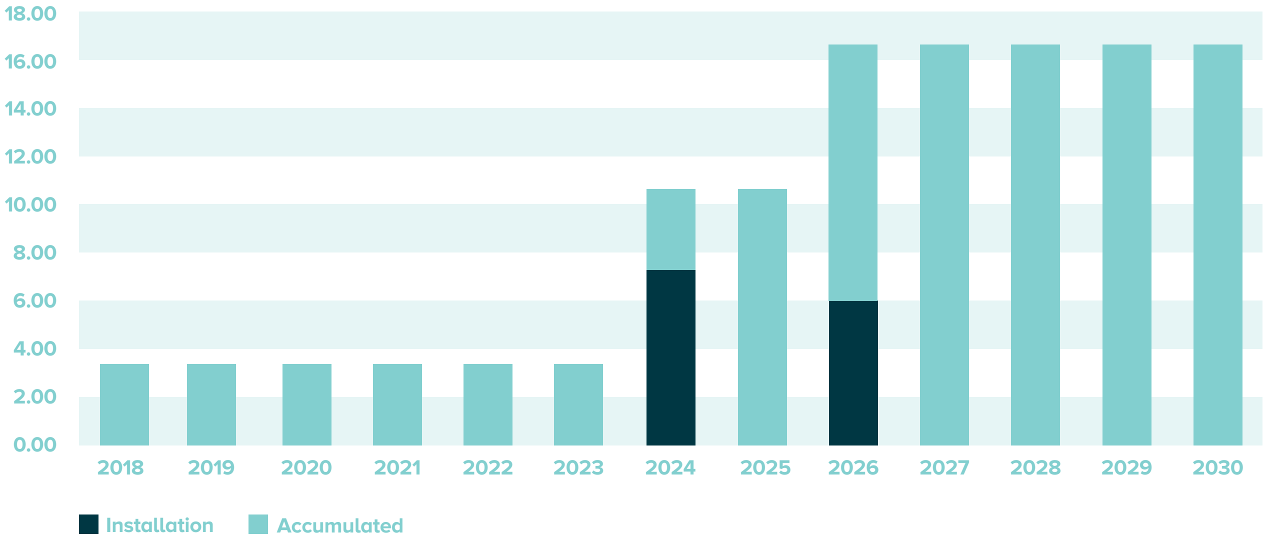


Figure 12. Expected evolution of installed wind power 2020-2030. Units: MW.

while always limiting the search to locations on rustic non-developable land with minimal agricultural value, as territory in Menorca is a scarce resource. With regard to territorial planning for renewable energies, the minimum distance of 500 metres from inhabited areas has been respected, as set forth by the PDSE. If the 30 MW of wind power installation is reached, and considering the foreseen average from the study of 2,750 equivalent hours (EH) at 80 m in height, a production level of 82.5 GWh/year would be achieved, which would entail a supply of 17.25% of the island's energy mix and a reduction of 22.5% of CO_2 emissions produced from Menorca's current level of electricity generation.

For this proposal to become a reality, the construction of a new 15 kV distribution grid must be carried out to connect the points of generation with the Ciutadella, Es Mercadal and Dragonera substations (dedicated lines), thus avoiding the elevated costs of carrying out evacuation directly to the 132 kV transmission grid. It is quite relevant that these new lines could serve as the backbone of a new meshed distribution/generation grid at 15 kV of high capacity, with a 400 mm^2 conductor to which all the substations would be interconnected. In the case of a fault in the evacuation line, the production of all of the installed wind power would not be lost. Furthermore, this new configuration would facilitate the system operator's task of grid management.

This configuration of wind energy generation has financial viability with returns in 12-15 years, when considering an electricity sales price of 46 €/MWh.

As for the implementation rate, we must understand that such installations are somewhat more challenging to negotiate than photovoltaic plants, given the need to create wind behaviour models for the chosen sites. Wind energy implementation in Menorca therefore adheres to what is depicted in figure 12. It is worth mentioning here that the penetration of wind energy in the Balearic Islands has always been problematic, with the Milà wind farm in Menorca as the only one currently in the entire archipelago, hence making the foreseeable implementation rate quite unclear. In view of such, the Menorca 2030 Strategy sets goals for photovoltaic implementation that are slightly higher than what would be strictly necessary to comply with the overall objective of reaching an 85% share of renewables in final energy generation. This helps to ensure the achievement of this objective in the case that wind penetration may be delayed.

2.1.3. Renewables integrated into urban settings

Possible locations for installations include buildings, parking areas, roundabouts or plots located in industrial parks. The technologies for consideration are low-power photovoltaic and wind, used for self-supply or returned to the grid. In hopes of reaching 30 MW of renewables in installed urban settings by 2030, substantial efforts must be made to maintain an implementation rate of nearly 3 MW per year.

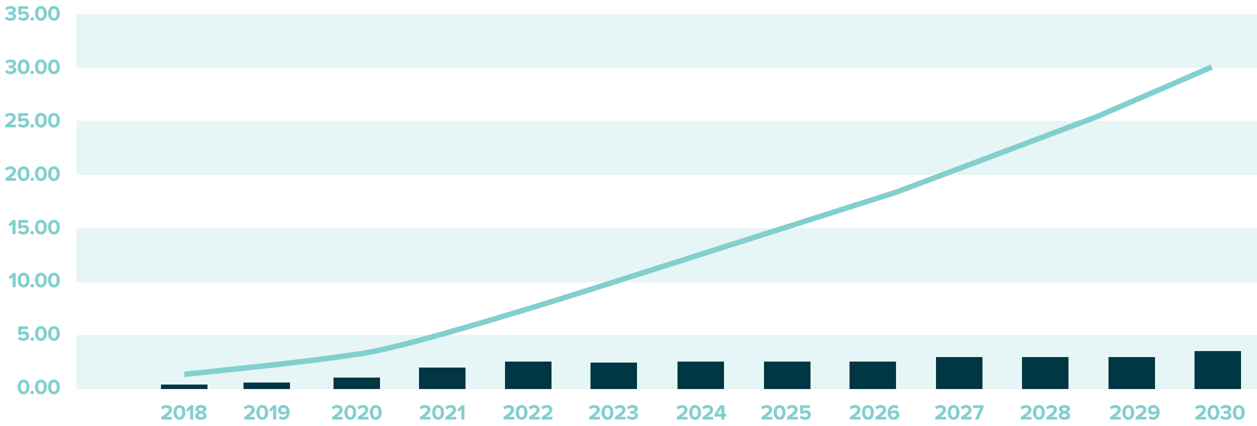
The Menorca 2030 Strategy heavily emphasises the integration of renewables within urban settings through the use of those already existent infrastructures that can integrate systems of renewable generation. Low power photovoltaic and wind (below 100 kW) are considered to be the most adequate technologies, as they can be used both for self-consumption, with or without surplus generation, as well as for injection into the grid.

Multiple possibilities for development have been forecasted based on the end use of the installation, which can be seen to the right.

- **SELF-CONSUMPTION IN THE RESIDENTIAL SECTOR**
- **SELF-CONSUMPTION IN THE SERVICE SECTOR (TOURISM INDUSTRY AND PUBLIC ADMINISTRATION)**
- **SELF-CONSUMPTION IN THE INDUSTRIAL SECTOR**
- **GENERATION ASSOCIATED WITH THE ELECTRIC VEHICLE CHARGING (IVE) INFRASTRUCTURE**
- **ROOF-TOP PHOTOVOLTAIC FOR INJECTION INTO THE GRID (FVC) OR CARPORTS**
- **LOW POWER WIND FOR INJECTION INTO THE GRID (EPP)**

INDUSTRIAL PARKS AND CAR PARKS, NICHES FOR PHOTOVOLTAIC ENERGY

An important niche that can provide a substantial increase in generation capacity, while also leading to the stimulation of local occupation can be found in industrial parks, which concentrate over 600,000 m2 of roofs of constructions built with asbestos fibre that are now reaching the end of their useful life. Here, policies could be implemented aimed at the energy renovation of such structures, combined with the replacement of fibre cement roofs and the fitting of photovoltaic generation intended for injection into the grid.



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Implemented	0.33	0.53	1.00	2.00	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00	3.50
Accumulated	1.65	2.18	3.18	5.18	7.68	10.18	12.68	15.18	17.68	20.68	23.68	26.68	30.18

Figure 13. Expected evolution of installed power capacity in urban settings 2020-2030. Units: MW

Additionally, the opportunity offered by the future penetration of electrical transportation must not be ignored. In such, the implementation of an infrastructure for charging electric vehicles (EVs) must be accompanied by similar growth in renewable generation. It is precisely in vehicle parking areas where we can focus a significant part of these efforts by placing photovoltaic carports and small wind turbines beside the charging stations. In this case, intelligent management of vehicle charging must be utilised as a potential support structure for the demand stability and management of the system operator.

There is currently a total of 1.6 MWp of photovoltaic generation installed in urban settings, a majority of which is destined to self-consumption and located on roofs. The prevision for 2019 is for growth of 30%, consisting of the implementation of an additional 0.53 MWp. For the growth rate to be sufficient to achieve the foreseen objectives, substantial efforts must be made to maintain a rate of nearly 3 MW per year.

On a whole, given the extent of foreseen photovoltaic integration, as well as that of the electric vehicle fleet, the development of a system of communication is required that allows for a joint operation that is reliable and efficient for all the available resources of the electric power system.

Quite relevant in this sense is the recent announcement made by IDAE regarding the allocation of a consignment of 4 million euros from European funds for the 2019-2021 period for the implementation of photovoltaic generation installations in parking structures, which would represent an initial stimulus for such generation on urban land. In addition to state funds, the Government of the Balearic Islands will dedicate specific allocations for investment in solar panels both on rooftops as well as carports through a variety of resources, such that car parks, including those owned privately, and rooftops of public buildings can house photovoltaic panels.

Should the introduction of renewable energies integrated into urban setting be greater that what is expected, the established goals for the introduction of land-based photovoltaic could be reduced.

2.1.4. Other technologies for generation

Although the mix of renewables set forth in the Menorca 2030 Strategy is based on photovoltaic and wind generation, the suitability of other renewable generation technologies cannot be dismissed. The energy potential of biodegradable waste, biomass, or wave power are studied energy sources that would contribute to reduced dependence on fossil fuels in Menorca.

Although the mix of renewables set forth in the Menorca 2030 Strategy is based on photovoltaic and wind generation, the feasibility of carrying out trials to explore the suitability of other technologies for renewable generation on an island level must not be dismissed.

The availability of biodegradable waste and biomass on the island has been thoroughly studied over recent years, hence deeming its contribution to the reduction of fossil fuel dependence as adequate. With regard to wave power, with a project proposed for execution in the port of Ciutadella, this is yet another viable option to be included in the energy mix.

Biodegradable waste

With regard to biodegradable waste, foreseen is the construction of a biodigester as part of the Milà Waste Management Area, with an electrical power generation of 0.5 MW resulting from the generation of biogas from biodegradable agricultural, livestock, domestic, commercial and industrial waste. This biogas plant is currently in its preliminary phase of development.

Biomass

As for biomass exploitation stemming from sustainable forest management, as well as waste from agriculture and pruning, studies carried out during the execution of the LIFE+BOSCOS project verified the energy availability for thermal uses at 46 MWh/year, as a significant potential for exploitation, subject to the adaptation of their installation by sports facilities and health centres that require large amounts of hot water. The Maó Sports Centre, Ciutadella Municipal Swimming Pool, Geriatric Assisted Living Residence of Maó, Mateu Orfila General Hospital and Es Mercal Municipal Swimming pool are potential recipients of this resource.

Wave energy

Another technology that has been identified as a potential key element in Menorca's energy mix is that of wave energy, which already has a specific project for its development in the Port of Ciutadella, with up to 4 MW of power and a virtually constant availability of energy, which is of particular interest during night hours.

Offshore wind and floating solar

Noteworthy is the fact that offshore wind and floating solar are emerging technologies for renewable generation that are currently still in the phase of technological development, but that during the operational time frame of this strategy could experience substantial advances, hence allowing them to complete the island's energy generation mix.

2.2. ENERGY STORAGE AND BACKUP SYSTEMS

Clear technical difficulties exist with regard to the operation and financial management of those energy systems with an elevated penetration of renewables due to their intermittent and non-dispatchable nature. Given the heavy dependence of renewable energies on meteorological conditions, there must also be a backup system to ensure electric supply in case of insufficient production. Energy storage devices, as well as the possibility of interconnectivity with other electric power systems, can help to alleviate this issue.

The integration of renewable energies in electrical grids is gaining ample acceptance at present. There are, however, notable technical challenges in the operation and financial management of such energy systems with elevated penetration levels of renewables, due primarily to their intermittent and non-dispatchable nature. Energy storage devices, like batteries connected to the grid, as well as the possibility of interconnectivity with other electric power systems, can help to alleviate this issue with the support they can provide to the energy system for the regulation of the grid's frequency or tension.

This section presents a preliminary analysis of the role that these devices can play based on the baseline 2016 conditions and the foreseeable evolution of renewable energy introduction. This study is based on the application of a methodology of impact evaluation and the study of various storage projects in insular systems with needs similar to those of Menorca's electric power system.

Given the elevated dependence on meteorological conditions for energy generation from renewable energy sources, a backup system will be necessary to ensure electricity supply in the case of insufficient renewable energy production. So for Menorca's electric power system to be viable with a high penetration of renewable energies, it is necessary to possess systems that allow for the use of generated energy at those moments when said energy is demanded by the final consumer. For this to occur, it is essential to include within this strategy a forecast for energy storage systems.

In general, storage systems can be especially favourable for islands, whose electric power systems face two great challenges; on one hand, the production costs of conventional generation is higher than for mainland systems due to variable costs like fuel; and on the other hand, the reliability of supply is more greatly affected by non-dispatchable technologies, as is the case of renewables. These technologies are especially useful in isolated systems with low installed power, as is the case for Menorca. This section is hence meant to be a starting point for a detailed study of the effects of different storage systems on the reliable operation of the island's electrical grid in scenarios of high penetration of renewable energies.

The standard to be used for the evaluation of reliability is criterion N-1, while taking into account, however, all available resources: renewable generation, interconnection cable, storage, and demand management resources (response to price by consumers).

Another necessity will be the implementation of a system for communication and control of the ensemble of production and storage resources, including systems for electric vehicle charging through the system operator so as to address reliable and efficient integration and management.

2.2.1. Simulations of generation and demand for 2030

Storage systems will be essentially of three types: large-scale stationary storage, storage located in urban areas and storage in electric vehicles. To determine the role of these support systems, simulations must be carried out regarding the system's operation for varying conditions.

The joint determination of the role of support, storage and interconnection installations is a problem that cannot be analysed in terms of energy, but must instead be done through daily simulations of the system's operation under varying conditions.

In this sense, the first step involves forecasting daily demand and the associated generation and grid conditions.

The data and results seen below have been obtained using estimations for generation and demand for 2030.

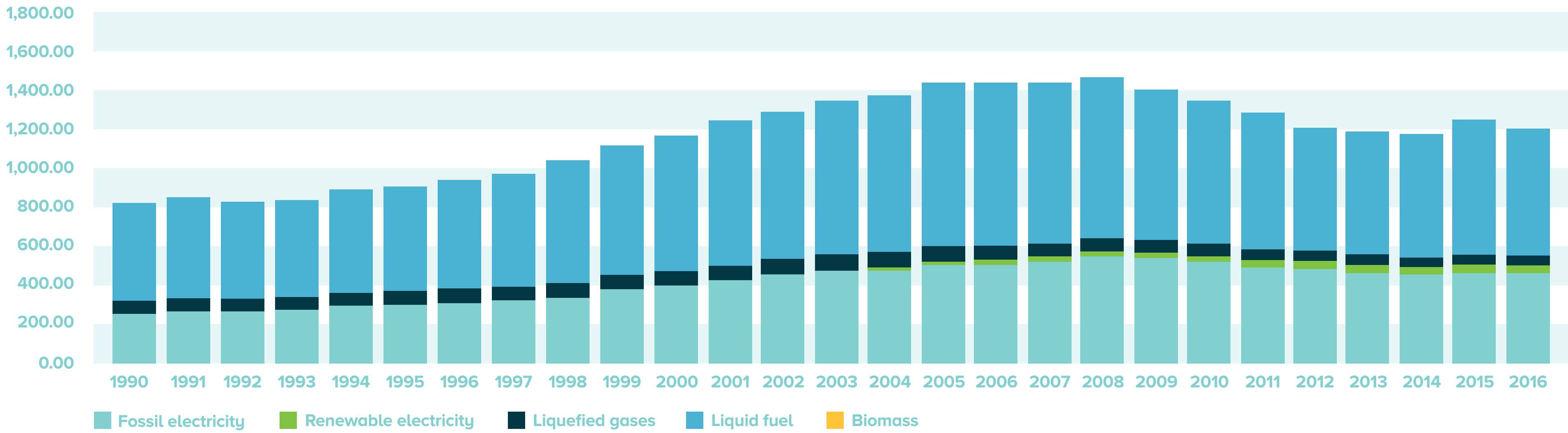


Figure 14. Baseline situation: Evolution of final energy by supply until 2016. Units: GWh.

EVOLUTION OF FINAL ENERGY IN MENORCA BY CARRIERS 2016-2030

Figure 14. Shows energy data for the situation in Menorca in 2016, the year used as reference so as to include the presence of the Mallorca-Menorca interconnection cable.

Figure 15. Shows the projected evolution of energy by supply in Menorca for 2030. This projection is based on, in addition to the progressive implementation of renewable generation, the estimated evolution of demand, which takes into account projected plant growth, efficiency of consumption processes and the emergence of new consumption processes like heat pumps, electric vehicles, etc.

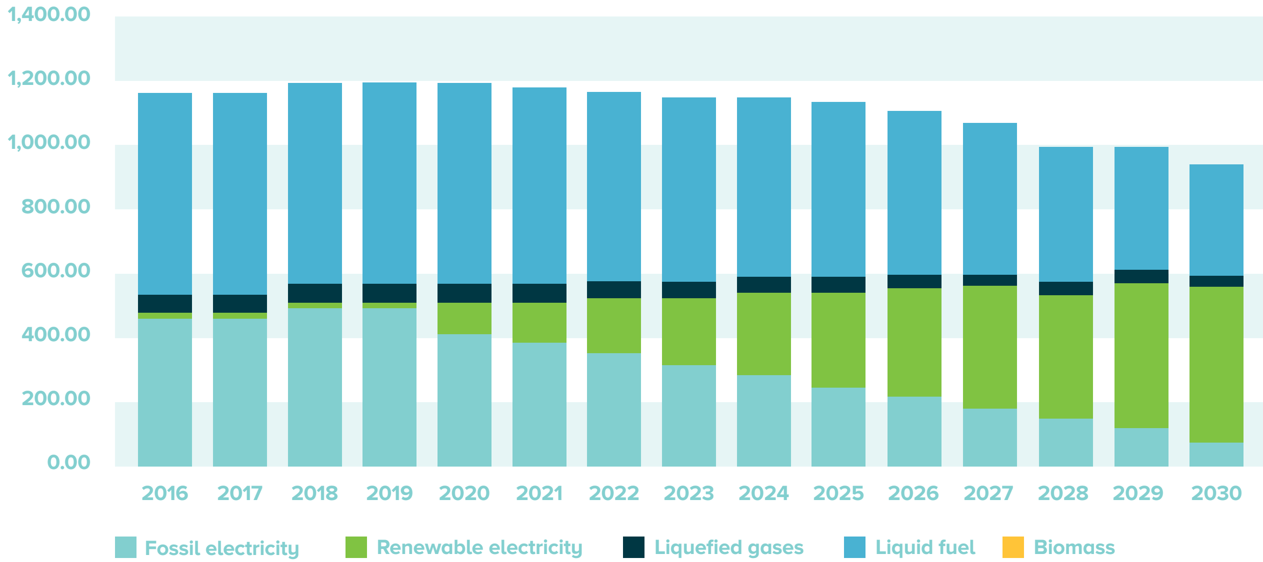


Figure 15. Foreseen evolution of final energy by supply for the period 2016-2030. Units: GWh.

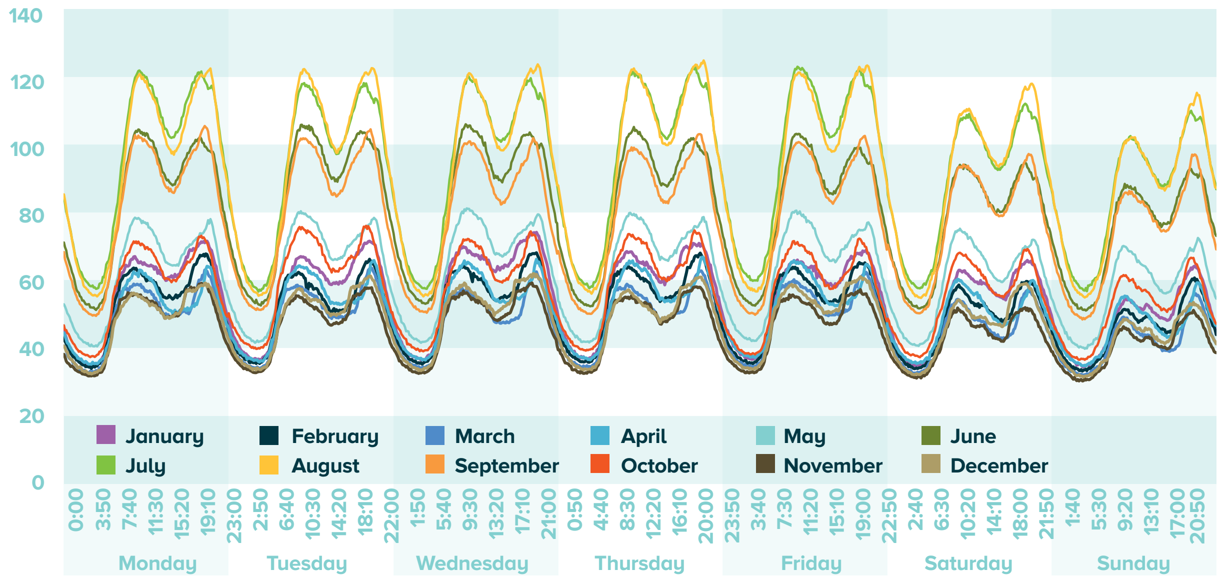


Figure 16. Estimated weekly consumption by month in 2030. Units: MW.

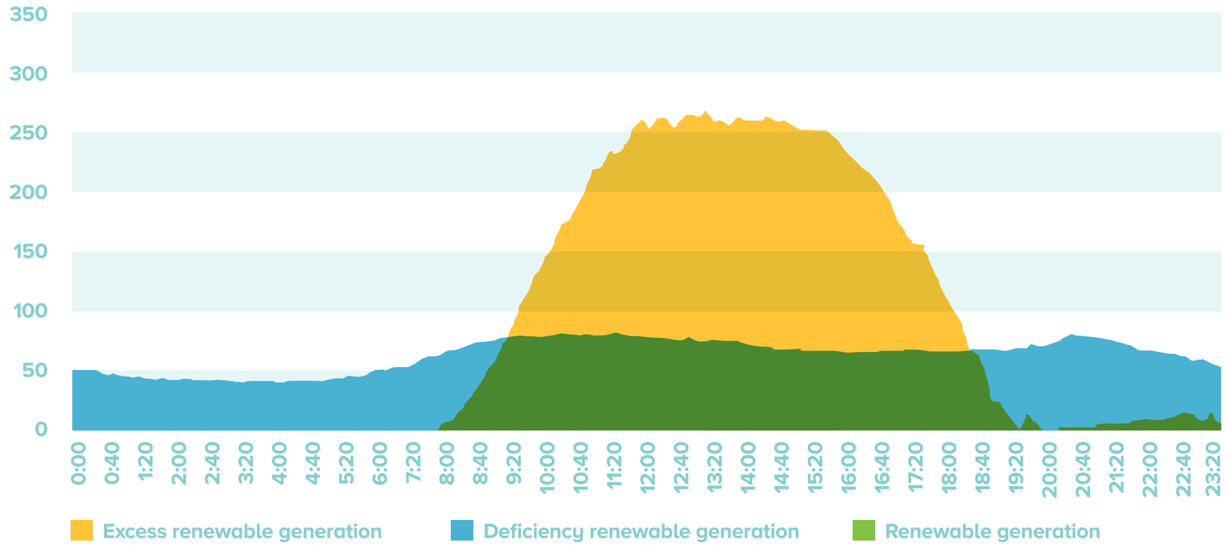


Figure 17. Hourly production forecast for renewable energies against demand for 18 April 2030. Units: MW.

ENERGY GENERATION AND DEMAND IN 2030

Figure 16. Forecasts for demand have been projected through analysis of the foreseeable behaviour of traditional and new consumers in daily energy consumption, as a fundamental element for the analysis of the system's operations. The figures show the estimation of average daily consumption per month, for the whole of the island of Menorca in 2030.

Figure 17. To complement the information required for the simulations of grid operations in 2030, and in order to determine the system's support necessities, daily generation curves should be created, as proposed in this document. In doing so, historical data for wind and photovoltaic production for one year have been used.

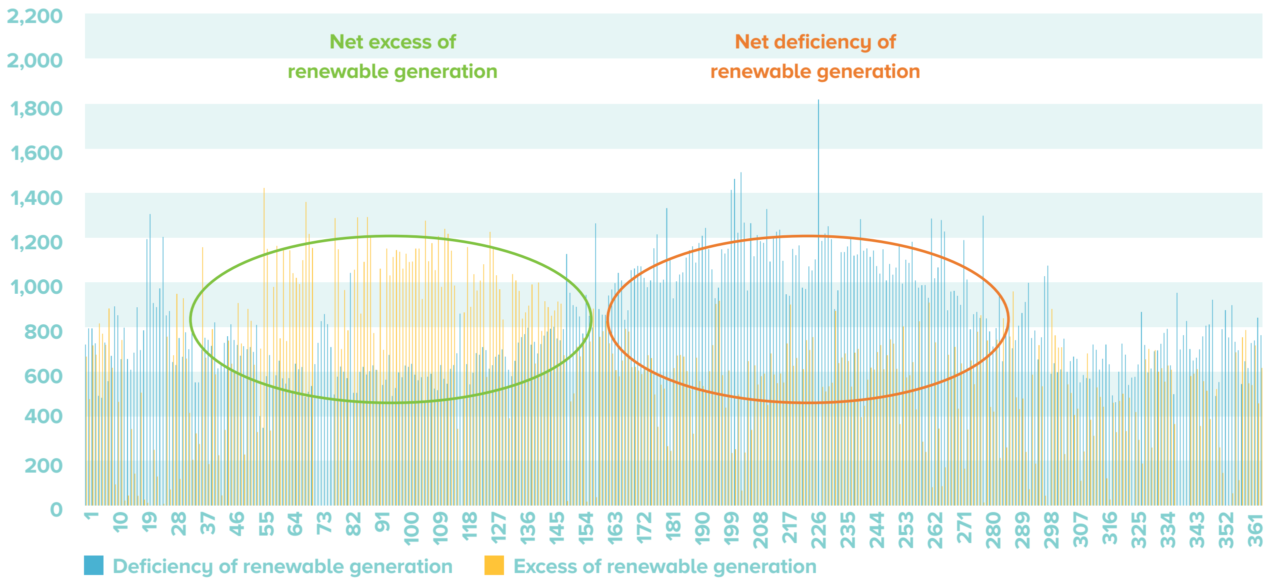


Figure 18. Potential excess and deficiency of daily renewable generation in 2030. Units: MWh.

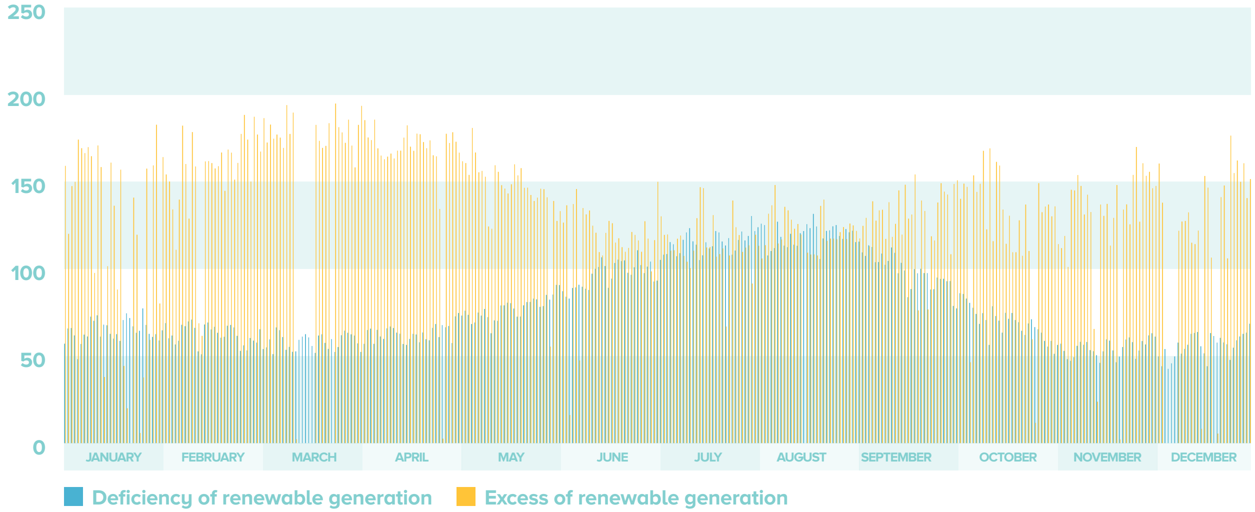


Figure 19. Maximum difference between renewable energy power and demand during the excess and deficiency periods of renewable energy in 2030. Units: MW.

Figure 18. In accordance with expected renewable generation and demand, it is possible to execute an annual analysis for the different periods of the year 2030 in which there are expected excesses or deficiencies in generation with renewable energies versus demand. Each day is characterised by certain hours (energy) in which demand cannot be covered by renewable energies and others in which such generation exceeds demand.

Figure 19. The result of a similar analysis can be observed in this figure, which depicts the maximum difference between renewable energy power and demand during the excess and deficiency periods of renewable generation.

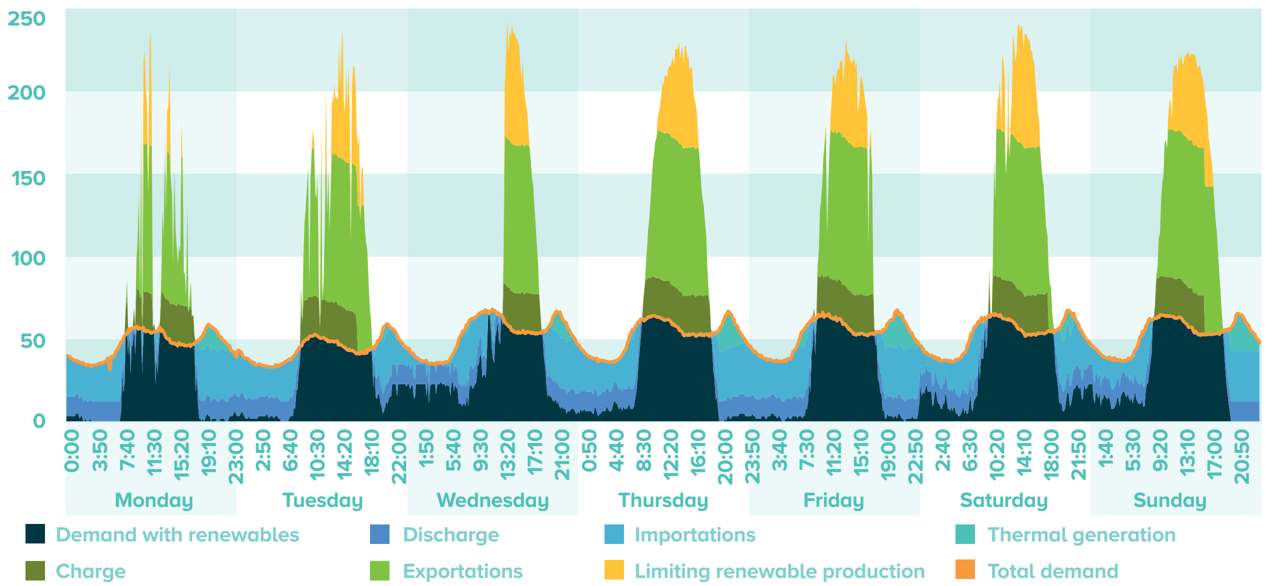


Figure 20. Simulation of daily operations quantifying the operational requirements (April 2030). Units: MW.

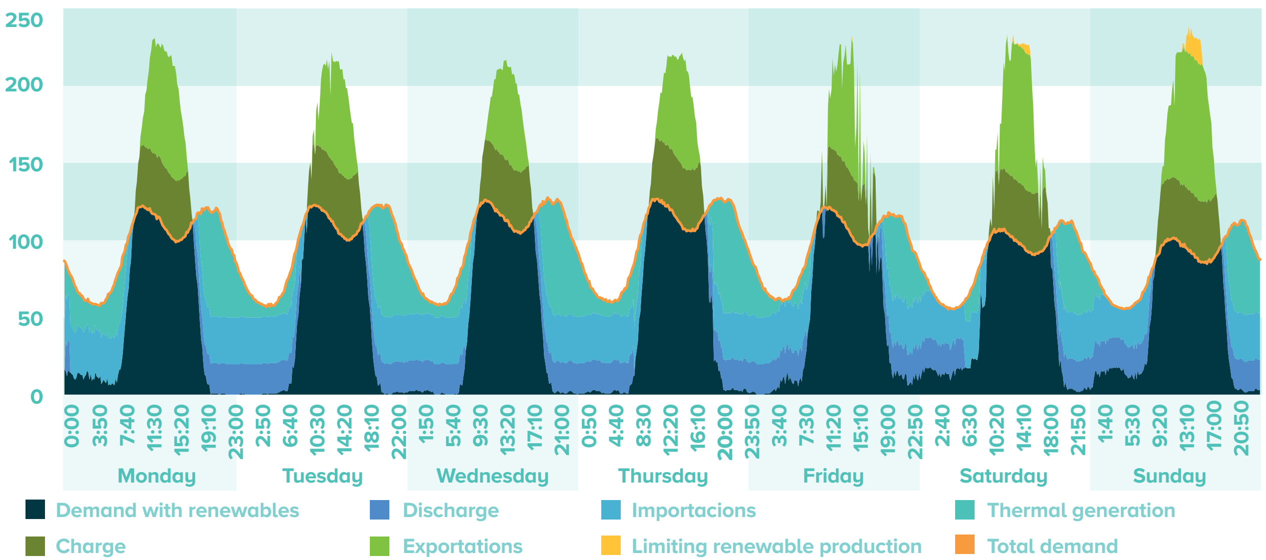


Figure 21. Simulation of daily operations quantifying the operational requirements (August 2030). Units: MW.

STORAGE MANAGEMENT IN DAILY OPERATIONS

Figure 20. To determine the expected backup necessities for Menorca in 2030, a simulation must be carried out for daily operations, as seen in the figure. The results are for one week in April of 2030, with a storage capacity of 400 MWh and 100 MW of maximum charge/discharge power. The simulated week is one of relatively low demand with substantial production from renewable energy. As can be observed, during that week it would be necessary to reduce renewable energy production (in yellow) during some periods, even if the maximum amount is stored and the maximum supported by the interconnection line is also exported.

Figure 21. This figure depicts the results of installing the same battery capacity for a week in August 2030. It shows that, as demand is greater, it becomes virtually unnecessary to reduce renewable energy production. It is worth mentioning that the depicted results are highly preliminary and more thorough analysis will be required (including equipment malfunction rates, etc.), as will be the ability to modulate the storage charge.

IMPACT FROM STORAGE CAPACITY ON GRID OPERATION

Figure 22. As a result of extending the aforementioned study to each day of the year, the impact of storage capacity on certain key indicators can be evaluated, as seen in the figure. These key indicators are the percentages with respect to power demand in Menorca for thermal generation needs, unused renewable power and power imported from and exported to Mallorca. This study must be complemented by a corresponding economic analysis.

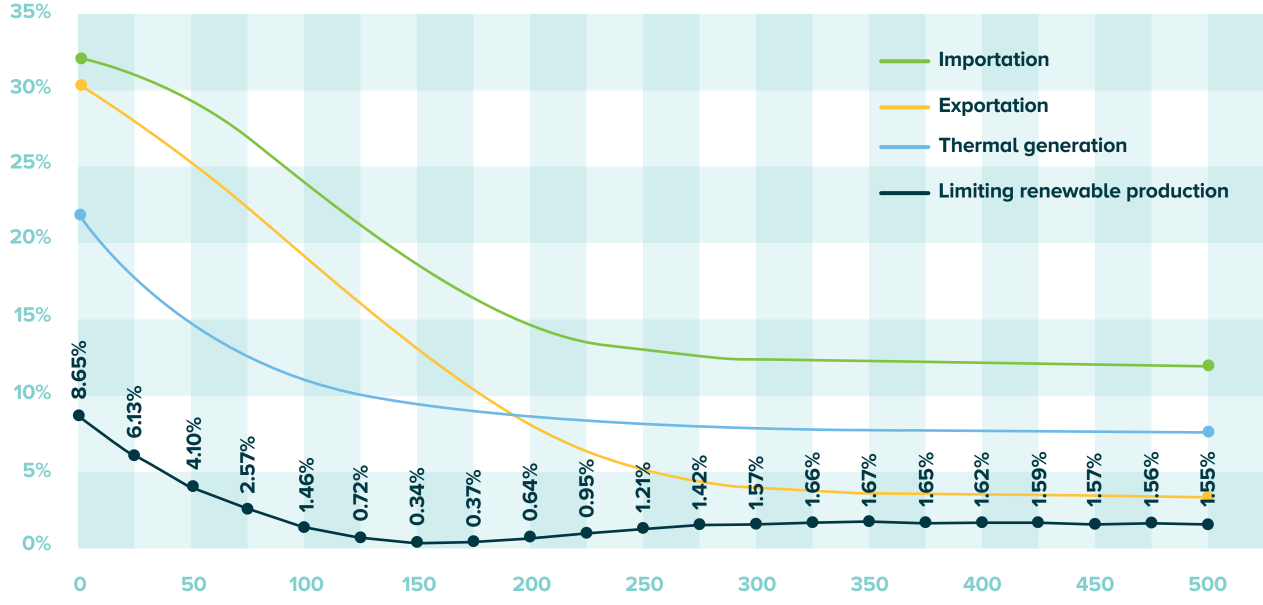


Figure 22. Impact from storage on grid operation. Nominal battery power (MW) - Capacity (4 h).

1 **Large-scale stationary batteries in the areas around existing substations.**
Such batteries, in addition to helping to optimise renewable generation, will aim to take part in complementary and reserve services in accordance with operational procedure. It is estimated that the storage provided by this type of batteries would imply the implementation of 196 MWh and 49 MW of charge/discharge power.

TECHNOLOGIES AND CAPACITY OF REQUIRED STORAGE

The results seen in the studies and the preliminary simulations introduced in the paragraphs above suggest the need for installation of a maximum storage capacity of 400 MWh, with charge/discharge power capacity of 100 MW. This capacity could be adjusted, and possibly reduced, with more thorough analysis. This storage capacity will be achieved via the use of different technologies.

2 **Batteries associated locally to photovoltaic generation plants** installed in urban areas and their surroundings, that will be operated either by aggregators or directly by consumers or generations. It is estimated that in 2030 there will be 30 MW installed for this type of installations, which will carry an associated storage capacity of 160 MWh, with a charge/discharge capacity of 25 MW.

3

Batteries associated with electric vehicles connected to the grid with dispatchable capacities. It is estimated that the capacity that will exist for this technology in 2030 will be 80 MWh with a charge/discharge power capacity of 20 MW, although it will be necessary to create more accurate scenarios regarding the presence of electric vehicles in different areas of the system, as well as their effectiveness (viability of the option of modulating their charge and discharge).

4

Demand management. Although this technology does not imply energy storage in such, it does provide similar flexibility that results from the rapid modulation of consumption. An operational capacity of 5% of demand is estimated, which translates into 6 MW of dispatchable power.

These accumulation systems are replicable and could be increased subject to the energy to be accumulated and the increase in the availability of renewable energy generated.

The proposed production profiles are adaptable to different sized photovoltaic systems and types of installations; both PV + battery connected directly to the grid as well as those found with loads (buildings, factories, etc.).

OTHER SERVICES OF STORAGE SYSTEMS

In addition to the management of renewable production, the storage system is able to provide other necessary services for the proper functioning of the electric power system, such as:

1 FREQUENCY CONTROL

So as to maintain the frequency within the grid's operational limits, the system operator is typically based on units of generation that can provide a power delivery ramp at a high enough rate to compensate for frequency deviations.

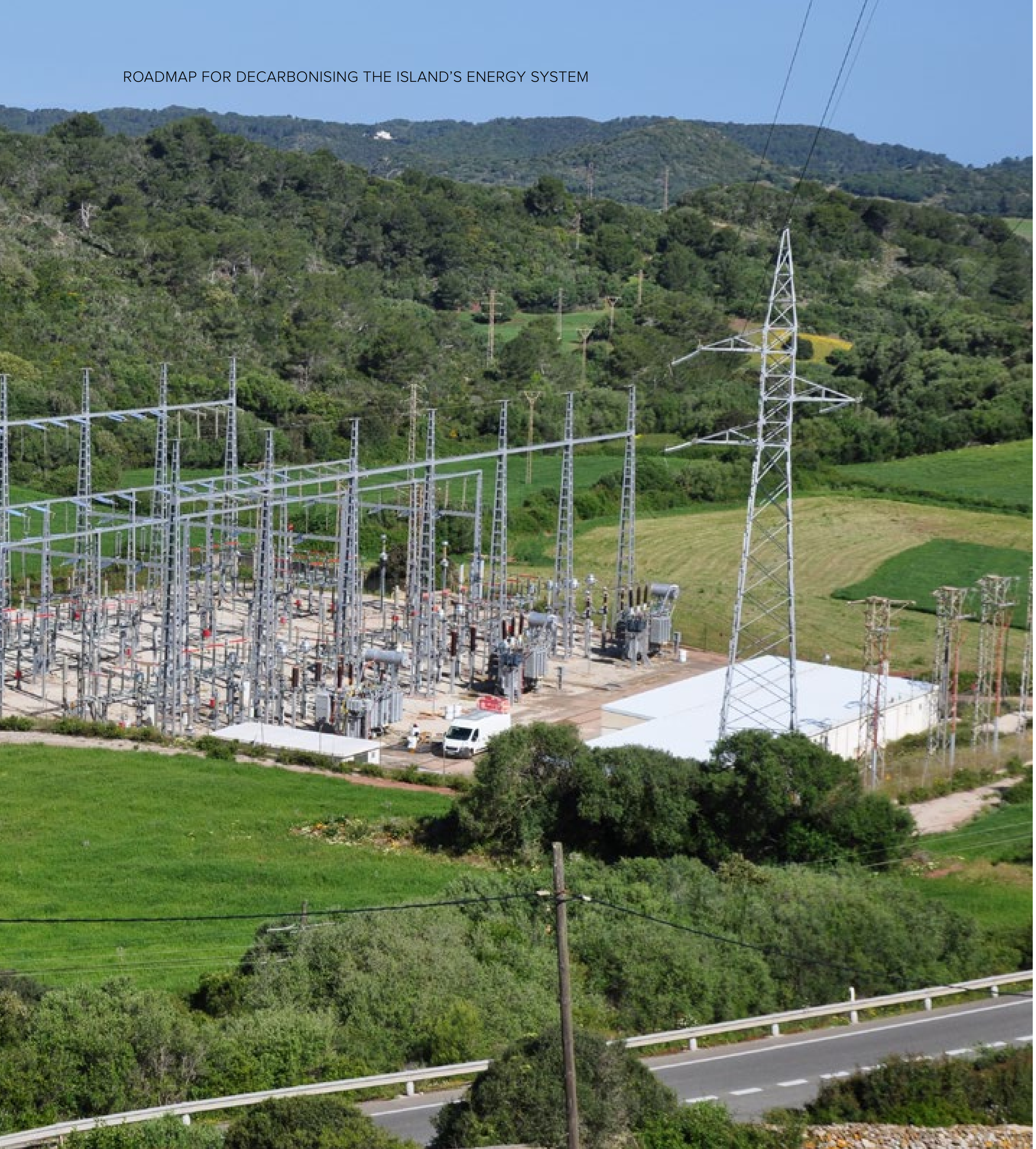
In possessing a storage system with batteries, a given power and energy capacity can be assigned for battery charge/discharge such that it may provide support in frequency control if there should be any deviation.

2 REGULATION OF TENSION

As it utilises the apparent power remaining from the batteries' energy conversion system, the storage system can inject/absorb reactive energy to maintain tension levels within the grid's operational limits.

3 BLACK START

The storage system can be used to provide a black start (self-start) in the event of a total loss of supply in the systems.



2.2.2. Integration of energy storage in insular systems

Storage options for optimal integration of renewable energies in the island's electric energy system is under consideration. Those available technologies and similar case studies from other islands are being evaluated, while the techno-financial criteria for the execution of a thorough simulation study are also being defined.

For insular systems, large-scale electrical storage has traditionally been based on hydroelectric facilities, like for example on the island of El Hierro (Canary Islands). However, such storage is less practical for systems with a high penetration of renewable energies, as these require rapid response and short ramp times. For this reason, the use of affordable and long-lasting electric batteries is on the rise in insular systems.

This section will discuss the use of energy storage as a tool to facilitate the integration of renewable energies into insular systems, as well how to improve the operation of existing diesel systems, while maintaining the system's reliability.

Several criteria exist for the adoption of storage solutions:

1

SYSTEM INTEGRATION:
A study of the necessities of the electric power system to determine the suitability of different types of storage and their integration with other components of the system.

2

EXPECTATIONS OF TECHNICAL CAPACITY:
There are multiple storage technologies that are still in the development phase. Their application could increase risk on a technical level.

3

MAINTENANCE:
Some storage options have critical maintenance requirements that must be quantified in both technical and financial terms.

The aim is to use these selection criteria to define the role that must be applied to energy storage in Menorca from a technical point of view, while also quantifying, through use of technical and economic indicators, the various existing options for storage to better respond to the established necessities.

The report "Electricity Storage and Renewables for Island Power" by the International Renewable Energy Agency (IRENA, 2012), describes several technologies for electrical energy storage used in insular systems.

First, lead-acid batteries, which represent an older type of technology with moderate costs and high dependability levels. These batteries, however, have a relatively short lifespan (between 3 and 10 years) and must be properly discarded or recycled. Lithium-ion batteries are common in mobile applications (such as cell phones and laptops), while they have higher initial costs than lead-acid batteries, but longer lifespans and lower capacity loss.

Flow batteries (specifically, vanadium-redox and zinc-bromide) have a long lifespan and low operational costs. However, these technologies are still relatively new in applications of electricity storage. Flywheel systems are the most suitable for short-term storage (less than 1 minute). Storage in ultracapacitors shows similar characteristics, allowing for support for the system's primary regulation through instantaneous inertia emulation and guaranteed supply continuity. Compressed-air energy storage (CAES) and pumped hydroelectric energy are typically only adequate for large-scale electric power systems (over 500 MW).

With regard to Menorca, it intends to store energy to help manage peak demand for the line to which storage is connected, its charge level, as well as provide auxiliary services like frequency regulation and tension control. This will hence prioritise the centralised use of storage around substations, although the study of decentralised storage is also of interest in the insular system.

Taking these key concepts into account, the following table details various study cases for energy storage in different insular systems with high penetration levels of renewable energy sources. These examples, which shall require thorough analysis, should be used as a basis for observing how energy storage systems are being used in insular systems, helping to improve grid reliability and functions in insular systems, thus facilitating the implementation of renewable energies.

SITE	POPULATION	STORAGE TECHNOLOGY	COMPONENTS OF THE ELECTRICAL POWER SYSTEM	SYSTEM SIZE
Bonaire, Venezuela	14,000	Nickel based	Wind/Diesel/ Energy storage	Wind: 14 MW, Diesel: 11 MW, Storage: 3 MW
Molokai, Hawaii	10,000	Lithium-ion	Solar/Storage	Solar plant: 4.88 MW, Storage: 3 MW - 15 MWh
Scilly, England (Smart Island Partnership)	2,200	Li-Fe PO_4 smart units	Solar/Storage Pilot virtual power plant (VPP)	(Foreseen) Batteries: 43.8 kWh Solar panels, residential: 450 kW (70 homes)
Åland Archipelago, Finland (FLEXe project)	30,000 on 6,500 islands	(Foreseen) Electric vehicles (V2G)/Lithium-ion/Hydrogen	Wind/PV/Biomass	(Current) 71.7% consumed energy: Submarine cable (AC) from Sweden 80 - 100 MW. 20.7% consumed energy: local wind

Table 1. Case studies for energy storage in other insular systems with high-level penetration of renewable energy sources.

Once the number of proposed storage technologies has been reduced, the remaining storage proposals must be characterised with techno-economic criteria. The following metrics are relevant in determining storage technologies:

- Energy storage capacity [kWh or Ah]
- Charge and discharge rates [kW or A]
- Lifespan [cycles, years, kWh-life]
- Efficiency [%]
- Initial capital expenditures, CAPEX [$/kW, $/kWh-cap, and $/kWh-life]
- Operating expenses, OPEX [$/MWh, $/kW-year]
- Energy density [Wh/kg and Wh/m^3]

By utilising these indicators to define the various storage options, and by carrying out analysis of Menorca's electrical power system as a basis for defining the system's necessities, a study of the different combinations of electrical storage typologies and their integration with other components of the island's electrical power system shall be proposed. This can be performed through use of analysis and design tools for systems like the HOMER simulation system.

The design parameters for the simulation will include the dimensions of the diesel generators and the renewable energy plants, as well as the different typologies of electric power storage. The results of the simulation will show the use of these storage systems to respond to the island's energy demand across different operational scenarios. The proposed techno-economic indicators will facilitate the selection of technologies and adequate dimensions in terms of dependability, grid reliability and cost. In addition to those mentioned above, also taken into account is the levelized cost of electricity, widely used for renewable projects, which includes the CAPEX and OPEX of investment in energy systems.

Finally, it is also noteworthy that there is not only one possible storage solution for insular systems, and storage may not be appropriate for all of the island's systems. Through a detailed study of the island's consumption and the characterisation of Menorca's electrical power system requirements, typology planning and dimensioning and the level of necessary storage for its electrical power system shall be determined.

2.2.3. Backup systems

Backup systems in an electrical power system using integrated renewable energies provide reliability and ensure demand coverage when renewable generation is low. In Menorca, the two possible backup systems are the submarine link with Mallorca and the thermal power plant in Maó. Both systems must evolve toward lower emissions in the future.

Backup systems are necessary so as to ensure the reliability of electricity supply in Menorca, as well as for the coverage of demand in periods of low renewable resources. This implies use of the submarine link with Mallorca and the thermal power plant in Maó.

These systems must however evolve toward reduced emissions. To do so, it is foreseen that in 2025 two of the four coal units of the Es Murterar power plant in Alcudia (Mallorca) cease to operate, and in 2030 the remaining two will follow suit. There are also planned improvements for the thermal power plant in Maó to reduce its emissions levels. These will be detailed below.

MALLORCA-MENORCA SUBMARINE LINK

The submarine link with Mallorca has been out of service since October 2017. The installation of a new interconnection, which will have an operational capacity of 35 MW, is in its final stages and is expected to be active in summer of 2020. With regard to the currently inoperative connection, its substitution shall be carried out starting in the year 2027, and will allow for an increased operational capacity of the link to nearly 90 MW.
The role of this line will be of vital importance in the future, highlighting the following aspects:

- It will allow for the implementation of larger amounts of renewables in Menorca's system thanks to the management of renewable energy in times of excess supply.
- It will allow for the maximisation of renewable production both in Mallorca and the Spanish mainland, with management of excess supply in these areas.
- It will allow for better overall management of the dispatch of generation in the Balearic Islands, reducing connected generation and the necessary spinning reserve in Menorca, providing, ultimately, cost savings to the system.
- As it allows for the connection of Menorca with a large-scale system, it will provide short-circuit stability and power to the system, increasing supply security. Thanks to this fact, the need for conventional connected units in Menorca to provide these parameters shall be significantly reduced.

MAÓ THERMAL POWER PLANT

Due to prioritising a gradual increase in electricity generation from renewable energies in Menorca, as well as the increased exchange capacity with Mallorca, the use of this facility will be substantially reduced over time, to be used only as backup in exceptional moments of high demand and low renewable production.

At present, the plant has three diesel motors that run on fuel oil (a total of 47.4 MW) and five gas turbines that operate with diesel (a total of 224.2 MW).

The use of such fuels results in the thermal power plant being responsible for 60% of Menorca's CO_2 emissions, 82% of its nitrogen oxide emissions (NO_x), 97% of its sulfur oxide emissions (SO_x), 69% of its particulate emissions (PM), and 26% of its carbon monoxide emissions (CO).

Anticipated for this period is the installation of a system for NO_x emissions reductions in the gas turbines, although in light of what is described above, the use of fuel oil must be limited as much as possible, and natural gas utilised in the turbines that are apt for its use, which correspond to 82% of the thermal power plant's installed power. In this sense, Endesa will develop a proposal for a move to natural gas at the thermal power plant that will involve:

- Adaptation of gas turbines TG3, TG4 and TG5 for use with natural gas.
- Adaptation of the diesel engines for use with diesel oil instead of fuel oil, foreseeing their dismantling in the year 2030.
- Construction of a liquefied natural gas (LNG) storage and vaporization system annexed to the plant for exclusive use.
- Modernisation of gas turbine TG1 with an Enhance GT module that allows for:
  - Increased available reserve on the island.
  - Increased redundancy in case of failure.
- Creation of a supply chain (virtual pipeline) for maritime transport of LNG in cryogenic ISO containers that link the Barcelona regasification plant with the port of Maó.

UNITS	POWER (MW)	CURRENT FUEL	ACTION
Diesel engines (BW 1, 2 and 3)	41	Fuel oil	Move to diesel oil
Gas turbines (TG 3, 4 and 5)	138	Diesel oil	Move to natural gas
GE gas turbines (TG 1 and 2)	66	Diesel oil	Modernisation of TG1 to Enhance TG module

Table 2. Configuration of generation units at the Maó thermal power plant.

The configuration of the plant's units can be summarised as seen in Table 2.

The plant's future operation, once conversions have been made, will therefore be oriented toward the utilisation of TG3, 4 and 5 as the basis for natural gas generation, resorting to TG1 as a reserve. The remaining units will remain as emergency backup.

The necessary investment has been estimated at 26.7 million euros for the adaptation of the plant and 12.8 million euros in annual expenditures for logistical operations (in this last case considering an estimated production of 500 GWh/year for 2021).

2.3. LAND TRANSPORT

Transport is responsible for approximately 30% of GHG emissions. The goals for reduced impact and emissions will be achievable through a strategy that includes the electrification of 50% of private vehicle usage for 2030 with its associated sustainable and efficient charging network. Additionally, specific measures for the service sector must be applied that allow for the electrification of taxis and rental vehicles, as well as measures for the decarbonisation of collective public transportation and freight transport.

As explained above, transport is responsible for approximately 30% of GHG emissions, as well as NO_x and particulates that significantly deteriorate the quality of the air we breathe. As a Biosphere Reserve, the goals that need to be established regarding reduced impact and emissions from transport must be extremely ambitious. To achieve them, the strategic approach to be followed should include:

ANALYSIS PHASE:

- Analyse the most representative transport segments and collectives on the island.
- Identify the transport segments with the greatest impact in terms of emissions.
- Evaluate the capacity of each of the collectives and segments to better adopt means of electric transport.
- Design, in accordance with energy analysis of the existing grid and the island's specific features (transportation, housing, workplaces), the requirements and infrastructure model for charging in Menorca.

DESIGN FOR PLANNED INTRODUCTION OF ELECTRIC TRANSPORTATION ON THE ISLAND BASED ON FIVE CORNERSTONES:

- Awareness and communication: educational and awareness campaigns.
- Charging infrastructure.
- Administration must lead by example: establishment of criteria for the strict greening of the acquisition of fleets or services in public transportation.
- Stimulate demand: incentives for the acquisition and use of electric vehicles, both for individuals and businesses.
- Economic advancement: development of new modes of transportation, support for Industry 4.0 entrepreneurs, regeneration of the industrial fabric, etc.

PROMOTE THE IMPLEMENTATION OF THE ELECTRIC VEHICLE (EV) IN EVERY FIELD, IN PARALLEL WITH INCREASED RENEWABLES IN THE ELECTRICAL MIX AND THE GRID'S ADAPTATION:

- Substitute fleets of combustion vehicles for EV:
  - Rental vehicles: 50% EV in 2030
  - Public transportation: 100% EV or zero direct emissions in 2030
  - Vehicles of public administration: 70% EV or zero direct emissions in 2030
- Promote shared-use vehicle systems with EV.

2.3.1. Private vehicles

To reach the goal of electrification of 50% of the total fleet of private vehicles in Menorca in 2030, between 2,000 and 2,500 vehicles must be replaced every year. To do so would require the creation of a strategy and plan for electric mobility that includes tax benefits and direct financial aid for the purchase of an EV, in addition to an awareness campaign and a competitive public infrastructure network.

At present, the island of Menorca has an automobile fleet of over 74,000 vehicles, of which only approximately 100 are electric.

To achieve a greater penetration level of electric vehicles, various measures to create incentives for their acquisition will be discussed with the island's different municipalities. These incentives may range from free parking in "blue zones" to discounted road taxes.

To reach the goals for electric vehicle penetration established in this study, it will be necessary to complement tax benefits with direct financial aid for the acquisition of this type of vehicle, in addition to those measures already envisaged by the Institute for Diversification and Saving of Energy (IDAE) to make prices more competitive for the general public.

Considering that of the 74,000 vehicles that circulate in Menorca, 50,000 are private vehicles, the substitution of the current fleet must occur at a rate of between 2,000 and 2,500 vehicles per year beginning in 2020, so as to achieve the goal of the electrification of 50% of private vehicles.

To reach these ambitious objectives, a strategy and plan for electric mobility must be unveiled and include:

- **Awareness and communication** regarding the advantages to both the community and individuals of opting for electric mobility.
- **A public infrastructure network** that complies with the following requisites:
  - Accessibility (interoperability) and 24-hour service.
  - Affordability: the public charging network must be intelligent, connected and at least 25% more competitive economically than the alternatives for combustion fuel.

• **Incentives and policy:**
- Municipal taxation coordinated with electric vehicle incentives: parking discounts, road taxes, business taxes, etc.
- Accessibility to restricted areas (highly relevant for freight transport, for example).
- Greater flexibility regarding timetable and availability in loading and unloading zones.
- Special taxi stands with preferential locations and charging for taxis.
- Priority for electric taxis when contracting out municipal services.
- Incentives for collectives in purchases for intensive usage (freight and taxi).

2.3.2. Rental vehicle fleet and taxis

The Law on Climate Change and Energy Transition in the Balearic Islands envisages the progressive electrification of the automobile fleet of rental vehicles. The vehicles for hire fleet has applied incentive measures from the Balearic Islands Government, and it is expected that in 2025, all taxis will be low emissions vehicles, with a gradual increase until 100% of taxis are electric.

Electric mobility in the services sector is one of the principal lines of action for Law 10/2019, of the 22nd of February, regarding Climate Change and Energy Transition in the Balearic Islands, which establishes certain required minimum percentages for emission-free vehicles over the progressive renovation of rental fleets, until reaching 100% of all renovations that take place starting in 2035. This Law lays down the objective of an at least 30% emission-free rental fleet for that year. This sector suffers notable impact due to the island's touristic nature, which annually doubles its fleet of rental vehicles during summer months.

Regarding the fleet of taxis and VFH (vehicles for hire with driver), the Balearic Islands Government has defined stimulation measures for the acquisition of low-emissions and electric vehicles. In this sense, it is foreseen that in 2025, all taxis will be low-emissions vehicles and, gradually, the number of fully electric taxis will increase despite the challenge presented by the current lack of fast-charging stations.

The strategy for consolidation of electric vehicles within the island's rental fleet must contemplate:

- Type of usage and user of these fleets.
- Sizing that should be executed for the public charging infrastructure so as to assimilate demand.
- Need for the involvement of the hotel sector when developing the connected charging infrastructure that must be provided to their guests.

With regard to the taxi and VFH sector, the following tools should be made available:

- Municipal taxation coordinated with incentives for electric vehicles (as with private vehicles): parking discounts, road taxes, business taxes, etc.
- Access to restricted areas.
- Special taxi stands with preferential locations and charging for electric taxis.
- Priority for electric taxis when contracting out municipal services.
- Purchasing incentives.

2.3.3. Collective public transportation

The supply of collective transportation in Menorca is not especially parallel with the actual situation, although for the purpose of achieving the decarbonisation of insular transport, the network of such transportation should be strengthened and improved while being supplied with zero-GHG-emissions vehicles.

The configuration of urban mobility in the cities and towns of Menorca revolves around the use of private vehicles as the primary option as a means of transportation for a majority of the island's residents, whose general perception of this situation can be attributed to the lack of supply of collective transportation, which is not especially parallel with the actual situation. In any case, for the purpose of achieving the effective decarbonisation of insular transport, in addition to those soft measures that disincentivise the use of private vehicles (gradual pedestrianisation of city centres, fostering the use of bicycles, etc.), it would be beneficial to strengthen and improve the network of collective transportation, in terms of both routes and frequencies, as well as the provision of vehicles with zero GHG emissions.

At present, Menorca has 42 lines of public transportation, whose energy consumption totals 5,800 MWh/year.

Actions in the collective public transportation sector:

- Remodelling of the public transport system, improvement of public transportation lines.
- Promote alternative means of transportation and facilitate intermodal transportation, offering access to and/or transport of bicycles and other means of low-impact individual mobility within collective transportation.
- Bolster the renovation of collective transportation vehicle fleets toward cleaner and more efficient vehicles with zero direct emissions, whether electric or with hydrogen fuel cells. Because these are vehicles with specific and well-programmed routes, the electrification of a majority of the buses would be the best option.
- Incorporate and incentivise collective transportation within the mobility plans for those work centres that move a large number of workers (for example: the Mateu Orfila General Hospital, the headquarters of the Island Council of Menorca, etc.).

2.3.4. Freight transport

Heavy transport requires incentivising measures for the modernisation of fleets. The final delivery of goods within population centres, as it involves greater complexity of routes and a reduced volume of distribution per distance travelled, requires strategies that prioritise light delivery with smaller vehicles and zero emissions.

Freight transport shows two clearly differentiated fronts or stages: heavy transport, consisting of the transport of large cargo to logistics distribution centres or freight transfer hubs, on one hand, and light-duty delivery (or last mile), consisting of final delivery to different population centres, on the other hand. It is evident that the energy intensity of the final delivery phase, due to the complexity of routes and reduced effective distribution volume per travelled distance, as well as its incidence in traffic flow, is far higher and more complex, leading to the need for profound change in the manner in which final delivery is presented in certain population centres with ever greater restrictions on road traffic.

Therefore, for the first stage of freight transport, the necessary measures would be more related to incentivising the modernisation of fleets, oriented toward substitutions with vehicles of zero or extremely low direct emissions of pollutants, to then be further reinforced by changes in municipal ordinances that facilitate or accelerate this modernisation, as well as including in urban planning the establishment of zones or areas with the necessary infrastructure to improve the transfer of goods for final delivery.

Adaptation of the final delivery process will be even more complex, for which the strategy must combine several actions that encompass both direct and indirect economic incentives, along with the adoption of measures for urban mobility and urban design that favour and prioritise light-duty delivery with smaller vehicles and zero emissions.

Heavy transport

Actions to strengthen regulatory measures of a European, state and regional nature that expedite the modernisation of fleets:

- Municipal taxation coordinated with incentives for electric and zero pollutant gas emissions vehicles: benefits regarding road tax, business taxes, etc.
- Priority access to restricted areas or zones, greater flexibility in timetable and availability for loading and unloading zones.

Light-duty transport

Incentives and policies focusing on total decarbonisation of final delivery of goods:

- Municipal taxation coordinated with incentives for electric vehicles: benefits regarding road tax, business taxes, etc.
- Access to restricted areas, with special attention given to their coexistence in pedestrian and limited traffic areas.
- Greater flexibility in timetable and availability for loading and unloading zones.
- Authorised transit in special lanes.
- Plans for areas set up to facilitate modal interchange to final delivery transport.
- Incentives for the use of ecological delivery vehicles with limited load capacity (bicycles with assisted pedalling for small delivery volumes and loads below 200 kg, and electric vehicles for loads between 200 and 400 kg), that will require preferential access to urban areas and areas set up to facilitate modal interchange.
- Delimitation of areas or sites in adapted zones of urban settings that allow for modal interchange from large-scale transport to final delivery, equipped with the necessary infrastructures and included in urban planning.

2.3.5. Infrastructure for electric vehicle charging

To achieve mass implementation of EVs in Menorca, it is necessary to develop a sustainable and efficient charging network that combines fast charging, convenient charging and connected charging, as well as the adoption of charging strategies that incorporate the EV into the electric power system.

At present, there is a rather well-developed network of charging stations in Menorca through municipally owned charging spots distributed across the island's territory that guarantee the autonomy of the electric vehicle in the entire territory. This network is made up of 20 dual charging stations distributed in the following manner: (2) Ciutadella, (1) Ferreries, (3) Es Mercadal, (2) Es Migjorn Gran, (2) Alaior, (5) Maó, (1) Es Castell and (4) Sant Lluís.

In addition to the already existing points, through use of the Balearic Islands tourist tax, the Balearic Islands Government has decided to provide definitive impulse to the network of existing charging points in Menorca to help achieve transition in the transportation model. To this end, in December of 2018 a support scheme was published for the installation of more than 20 fast charging stations (over 30 kW) and 15 new semi-fast charging stations in Menorca over the following 5 years.

There are also financial support schemes for the installation of private charging stations that allow businesses to easily charge their own vehicles on site.

This infrastructure of charging stations has been integrated by the Balearic Islands Government into a platform known as MELIB[10], so as to jointly manage user demand and make future plans for the development of a charging management system. This will help adapt consumption in electric vehicle charging to the needs of the electrical grid such that the power load at the demand stations can be reduced, or even use the energy from the connected vehicles' batteries to later charge them at times of lesser demand.

In the short and medium term, the charging infrastructure will be designed for the mass implementation of electric vehicles on the island, bearing in mind two core ideas:

1. More sustainable and efficient transport. In the interest of "converting" combustion-based transportation into electric traction-based transport, we must adequately scale the charging infrastructure to equate the electric vehicle, in terms of practicality and to the greatest extent possible, to the combustion-based vehicle. Connected charging (slow charging) is the reference when conceiving a model, although in the long term, we cannot ignore the necessity for a charging model for vehicles that do not have a fixed parking space (fast charge).

2. Sustainable consolidation of electric vehicles and their contribution to the system. Intelligent charging integrated at all levels must allow for a reduction in the required investment in networks, while also improving the incorporation and management of the island's renewable generation mix.

With these two core ideas in mind, action must be taken regarding:

- **Public charging:** support for the strategy, creation and maintenance for public charging –with an adequate mix of fast charging, convenience charging (semi-fast) and connected charging (slow)- that allows for the viability of the business model, burdened by extremely high fixed costs.
- **Modernise and digitalise** networks to deploy intelligent charging, and thus the mass adoption of electric mobility in residential buildings and places of work.
- Develop **charging strategies** that facilitate the integration of electric vehicles in the electric power system, especially for large fleets, such as vehicle to grid (V2G) or grid 4 vehicle (G4V) strategies.

[10] ***MELIB:*** **<https://www.tib.org/ximelib/public/map.xhtml>**

2.3.6. Active management of electric vehicles

It is highly important to properly organise the increase in electricity demand caused by the electrification of land transport. A network of interconnected EV chargers that can manage the information supplied by users and information received regarding grid status will be necessary.

The electrification of land transport implies a reduction in the direct consumption of fuels derived from crude oil, but will also result in a substantial increase in the island's electricity demand.

If this increase occurs without adequate preparation, that is, allowing users to charge their electrical vehicles without any type of restrictions, significant investment would be necessary to strengthen and expand the current infrastructure associated with transmission and distribution grids, as well as considerably increasing the inefficiency of the electrical power system.

We can therefore conclude that to achieve optimal integration of electric vehicles, it will be necessary to carry out coordinated charging management based on the operational conditions of the electrical power system, especially true in Menorca's case. This management will not only minimise the aforementioned complications, but will also allow electric vehicle charging to become a useful resource for grid operators.

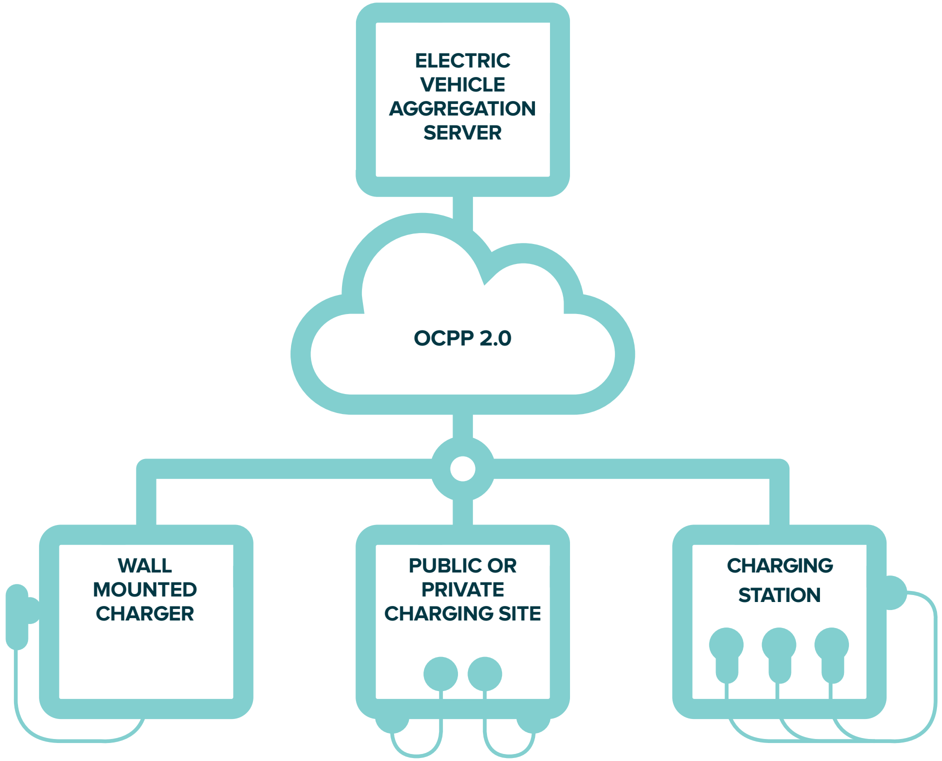


Figure 23. Centralised management of electric vehicle chargers.

For EV charging to be manageable on the island, the different types of chargers to be installed must comply with a series of requisites from a communications perspective. The proposal would involve chargers (charging modes 3 and 4) that are installed in dwellings, public and private parking areas, and charging stations so as to individually or collectively manage the charging conditions for the connected vehicles based on information provided by users and data received regarding the state of the grid (pricing signals or peak power demand). Accordingly, said chargers must be able to receive signals from third parties in accordance with the technical specifications of the OCPP 2.0 communications protocol, via secure connections by Internet or an allocated private network.

The chargers with greater installed power will thus be suitable for integration within a management system that will allow those more flexible consumers to reduce the charging costs of their EV, while also facilitating the management of the electrical power system by grid operators.

2.3.7. Complementary measures for emissions reductions

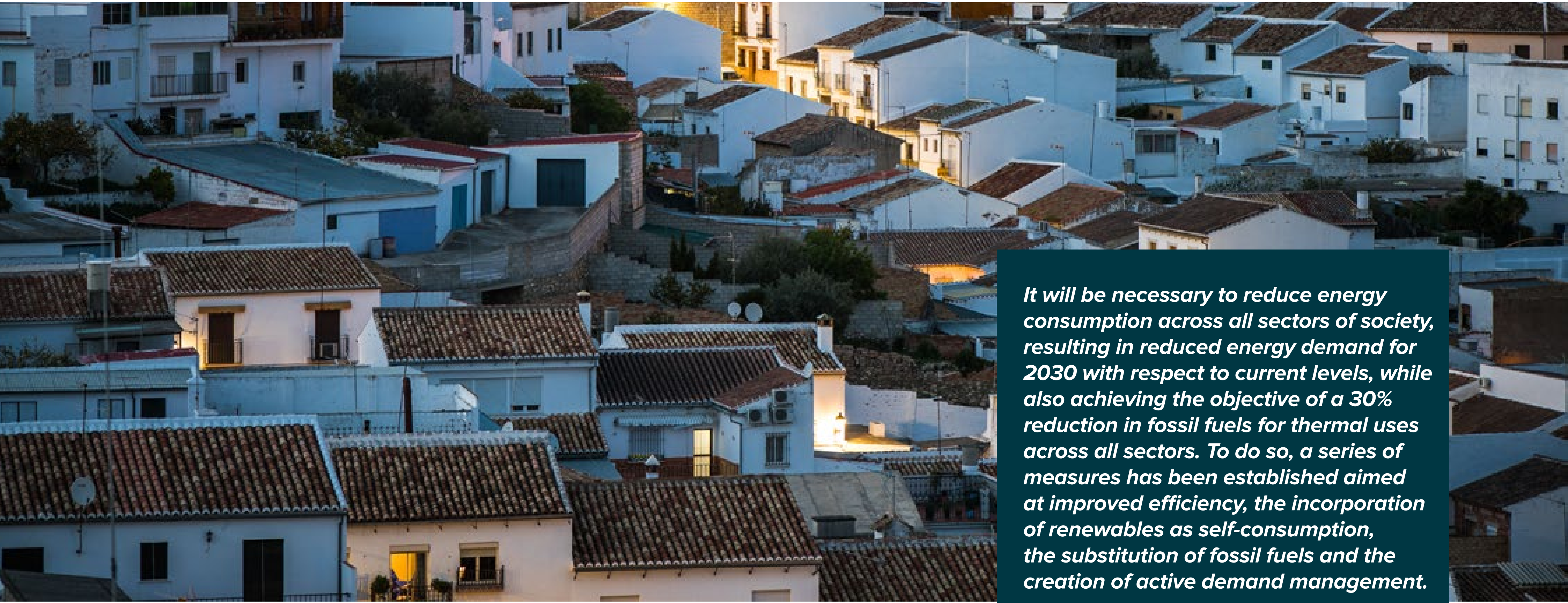
Beyond achieving the primary goal that is the electrification of land transport in Menorca, a series of other complementary measures should be taken between 2020 and 2030 to provide alternatives to private motorised transport and thus reduce the associated energy demand.

Between 2020 and 2030, it will be necessary to carry out numerous complementary measures beyond those mentioned above regarding transport, so as to ensure a reduction in emissions derived from the island's land transport. Most of these will need to be developed on a municipal or insular level.

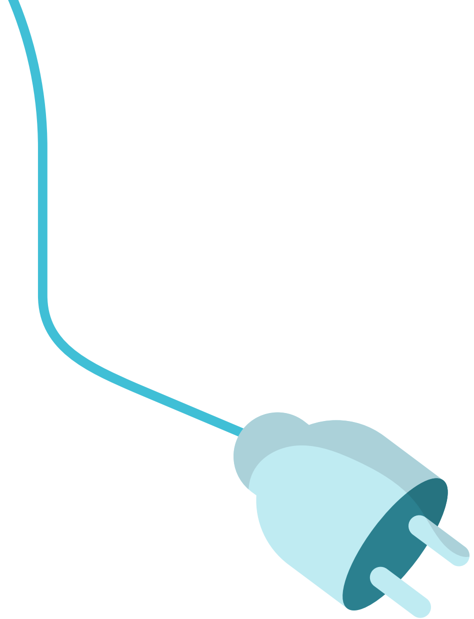
MOST RELEVANT MEASURES:

- Disincentivise private vehicle usage, through measures of alleviation of traffic in urban settings.
- Encourage bicycle usage through additional kilometres of bike lanes and the promotion of availability of rental of traditional and electric bicycles. Also attractive in this sense is the possibility of work centres providing a fleet of bicycles for short journeys.
- Urban planning that includes actions regarding mobility and emissions reductions. Noteworthy on this matter is the fact that the Insular Council of Menorca is the competent administration for the island's territorial planning, and city halls are responsible for adapting their own urban planning to this territorial planning.
- Incentivise low-emissions vehicles and/or more efficient systems with measures like, for example, the delimitation of areas of transit that do not allow high-emissions vehicles, or special parking for shared or low-emissions vehicles.
- Tax benefits for alternatives to combustion-based vehicles (road tax, "blue parking" zones, etc.).
- Consider solutions for school transport through collective transportation and improved access on foot, school paths and healthy routes.
- Promotion of carpooling: ride-sharing options.

2.4. EFFICIENCY AND ACTIVE DEMAND MANAGEMENT



It will be necessary to reduce energy consumption across all sectors of society, resulting in reduced energy demand for 2030 with respect to current levels, while also achieving the objective of a 30% reduction in fossil fuels for thermal uses across all sectors. To do so, a series of measures has been established aimed at improved efficiency, the incorporation of renewables as self-consumption, the substitution of fossil fuels and the creation of active demand management.



2.4.1. Residential sector

To achieve improved energy efficiency and reduce consumption in the residential sector and its emissions, solutions include the substitution of fossil fuels, the improvement of building envelopes, self-supply and active demand management. Also vital is social awareness to foster consumer participation, as well as the development of new local regulations that guarantee that new buildings reach zero, or virtually zero, energy consumption levels.

According to data from energy analysis in Menorca, the residential sector represents 17% of the island's final energy demand, of which, electricity makes up 74.3% (45% of the total electrical energy demand), fossil fuels represent 22.9% (diesel oil and liquefied petroleum gases [LPG]) and finally biomass, 2.9%. Fossil fuel demand from this sector makes up 30% of its total on the island, without taking into account demand from transport (land, air and maritime).

As mentioned above, it is important to foster the implementation of generation from renewable sources in the electrical installations of individual consumers as well as in collective installations, but it is also necessary to reduce energy demand in the residential sector. This can be achieved via improvements made in energy efficiency associated with the sector (improved envelope and more efficient installations). In this sense, dwellings will reduce their energy consumption while also improving the comfort of their inhabitants. There will also be movement toward the replacement of installations that utilise fossil fuels (LPG and diesel oil) for more efficient technologies that better respect the environment.

With regard to newly constructed residential buildings, new local regulations will be developed to ensure that these buildings integrate all the proposed measures included in this document, plus other specific directives for this type of installations, in hopes of achieving zero, or virtually zero, consumption levels. Finally, it is noteworthy that the benefits of this new energy model will also benefit the community thanks to job creation, a reduction in energy poverty and the overall improvement of individuals' health.

SELF-CONSUMPTION FROM RENEWABLE SOURCES

The objective is the large-scale expansion of self-consumption through the island's constructed power stations, primarily individual photovoltaic self-consumption, while also of a shared nature. The overall goal is the installation of at least 30 MW underself-consumption between the residential sector and the remaining sectors, excluding the aforementioned photovoltaic solar farms.

Royal Decree 244/2019, of April 5th, which regulates the administrative, technical and economic conditions of electrical energy self-consumption, contemplates a favourable scenario for the development of self-consumption. The simplified compensation mechanism, as well as the normative regulation of collective renewable self-consumption installations in residencial communities, serve as a good starting point for the progressive integration of renewables in the residential sector.

In the initial period of 2019-2021, and by initiative of the Ministry of Ecological Transition, via the Institute for Diversification and Saving of Energy (IDAE), ERDF funds are already available, allocated to the fostering of self-consumption on the island with a total sum of 5 million euros. Conservatively calculated, it is estimated that these funds could result in the implementation of 1,300 new installations and a total of 4 MW of installed power under self-consumption for this period in Menorca. At the same time, the Balearic Islands Government allocates annually in its budget an item for nearly 2 million euros for the promotion of self-consumption in Balearic Island homes and industries. Although this is not specific to just Menorca, it does in fact complement the IDAE aid and can continue to stimulate the growth of self-consumption.

In this sense, notable is the impact that the advancement of self-consumption can produce on Menorcan society in terms of local economy, but also in terms of the sensitising effect, direct implication and awareness of its community.

On one hand, the development of these small-scale domestic installations will certainly entail reactivation and positive impact on smaller installation companies in the island's renewable sector.

On the other hand, the existence of domestic self-consumption installations will have a positive effect on social awareness regarding energy consumption. It will also entail a gradual reduction in demand from the residential sector compared to the current electric power system, as an exemplifying effect for the general population regarding the options for renewable generation in homes, while also serving to disincentivise unnecessary consumption.

ENERGY EFFICIENCY

A 30% reduction in energy demand via improved energy efficiency is one of the European Commission's primary goals for the 2030 time frame. In this sense, there are two proposed types of actions for improvement made to energy efficiency. On one hand, improved building envelopes will be promoted, which will allow not only for reduced demand associated with climate control, but also to increase users' comfort level inside their homes. On the other hand, the use of more efficient climate control installations that do not use any fossil fuels whatsoever will be encouraged.

IMPROVEMENTS TO BUILDINGS' THERMAL ENVELOPES

The furtherance of energy efficiency in buildings is one of the key measures on the path toward an overall reduction in energy demand on the island. According to analyses made during the initial phase of the Strategic Directives of Menorca, there is substantial work to be done regarding the improvement of the thermal efficiency of the existing constructed power stations in Menorca. The island's mild Mediterranean climate favours buildings' correct bioclimatic operation with a correctly insulated envelope, solar protection, natural ventilation and minimal air leaks. If these measures are implemented, the energy consumption required to heat and cool buildings can be considerably reduced while still attaining maximum comfort levels.

In this context, the priority actions for energy renovation made to existing buildings' envelopes are the following:

1. **Increase thermal isolation**, with emphasis on the elimination of thermal bridges.
2. **Improve the performance of openings** (doors, windows, etc.), through the installation of new and more efficient joinery and glazing that incorporate features of solar protection.
3. **Incorporate bioclimatic strategies:** cross ventilation, thermal inertia, passive winter solar harvesting systems, the use of vegetation and other materials to modulate the temperature inside buildings, etc.

Additionally, the island's territorial and urban planning must foresee measures in this context, facilitating energy renovation and promoting the incorporation in new constructions of the highest requirements in matters of building efficiency.

These measures, both for the constructed residential power installations and new construction, must also be complemented by other supplementary measures:

4. **Facilitate requests for licenses** for energy renovation in buildings and for the implementation of efficient systems and self-consumption.
5. **Promote pilot projects** to demonstrate the different typologies of buildings, raising awareness of the process and its results.
6. **Establish tax benefits** for energy renovation and low-consumption buildings.

IMPROVEMENTS RELATED TO END USE

To reduce the island's dependence on fossil fuels, from a point of view of demand associated with end use in the residential sector, it would be necessary to foster the utilisation of more efficient technologies that require other sources of energy. The principal end uses related to the utilisation of fossil fuels in this sector include heating systems, domestic hot water and kitchens.

Based on this analysis, the installation of solar collectors (thermal solar energy) or hybrid panels (thermal + electrical energy) with thermal storage could signify a substantial reduction in fossil fuel requirements in end uses, like domestic hot water (DHW) and heating.

Their installation will therefore be promoted in existing residential buildings, especially for collective installations.

Considering additionally a scenario in which electric energy production shows a high participation level of renewable generation, advancement in the substitution of diesel oil and LPG systems for systems based on high-efficiency heat pumps for heating and domestic hot water will represent a significant improvement in the decarbonisation process for the residential sector.

Finally, the installation of biomass boilers in homes to substitute diesel oil and liquefied petroleum gas (LPG) is yet another alternative that must be fostered. In this context, and as discussed in section 2.1.4. on "Other Technologies for Generation", it is of notable importance to bolster actions for the attainment of this resource in Menorca as well.

In addition to the aforementioned measures for the reduction of energy demand in the residential sector, also of notable interest for the island would be the execution of complementary programmes for the promotion of more efficient electrical appliances, with special emphasis placed on the use of induction cooking to substitute traditional stoves, which currently operate using one of the LPGs.

EUROPACE ADVANCEMENT

With regard to the renovation of existent buildings, noteworthy is Menorca's potential for stimulus from programmes such as EuroPACE[11] , for the implementation of pilot schemes on a municipal level.

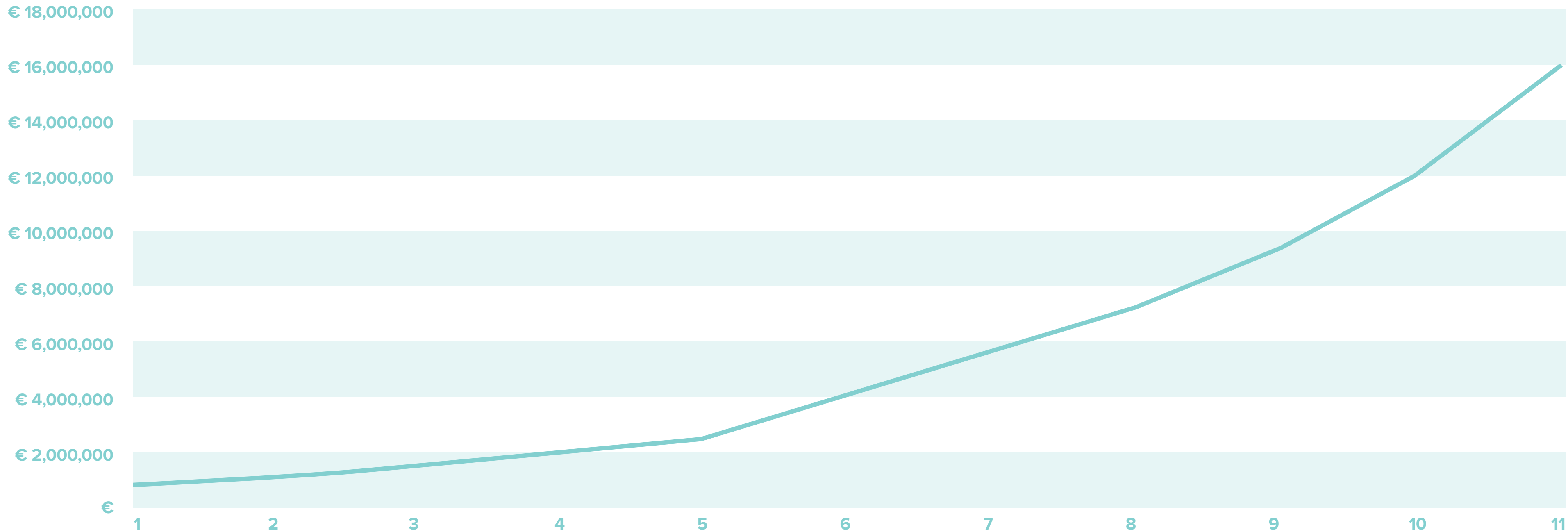
The PACE mechanism (Property Assessed Clean Energy) is a scheme that has been used in the United States of America to facilitate the financing of building envelope improvements so as to improve their energy efficiency.

[11] <http://www.europace2020.eu>

The implemented mechanism includes tax financing, as a type of financing tool utilised to attain contributions from private investors for building improvements that meet a "valid public purpose", such as energy savings or production. Investors are assured return of their investment and the interest for the administrations' tax revenues. The beneficiaries of such financing gradually make repayment via a levy on their annual property taxes, normally over an extended period (up to 25 years). Additionally, if the dwelling should be sold, repayment of the outstanding financing can be transferred to the new owner.

EuroPACE is a form of tax financing that is based on the existing relationship between municipalities and their residents: specifically the property tax scheme.

Expected total investment for the 2020-2030 period reaches 68 million euros, distributed as depicted in the following figure.



Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
% Accumulated	5%	7%	9%	12%	16%	25%	35%	45%	58%	75%	100%
Accumulated investment	806,025 €	1,128,435 €	1,450,845 €	1,934,460 €	2,579,280 €	4,030,125 €	5,642,125 €	7,254,225 €	9,349,890 €	12,090,375 €	16,120,500 €

Figure 24. Evolution of anticipated EuroPACE investment in Menorca 2020-2030.

ACTIVE DEMAND MANAGEMENT

The proposed objective of increasing the share of renewable energy in the island's electricity generation mix to 85%, from a technical perspective of electric power system operation, implies the need for more flexible demand.

The residential sector represents 45% of the total electrical energy required by end users in Menorca, and consequently achieving the active participation of these consumers in operational activities will be fundamental to reach this objective. In this context, efforts in social awareness will be determinant to ensure the success of this participation. In line with previous experiences on a global level, the principal end uses associated with the electricity demand of residential consumers that can be managed externally would involve climate control in dwellings (air conditioning and heating) and domestic hot water.

In light of these needs, it is proposed to establish in the corresponding regulations that, in newly constructed housing or existent dwellings that require changes to or the addition of a control system, so as to take part in a demand response programme, thermostats or the control hardware associated with such aforementioned end uses (climate control and DHW) can be securely connected to a third-party local network (Ethernet or Wi-Fi). This would allow them to receive external price signals or command actions according to the technical specifications in the OpenADR 2.0b communications protocol, as well as allowing for behavioural configuration of said installations based on the signals.

The proposed thermostats and control devices will be able to automatically plan the functions of the equipment associated with the cited end uses, taking into account the users' habits, the selected comfort levels, previously received price signals and expected meteorological conditions. Consumers from the residential sector can thus take part in future demand response programmes, which will imply additional benefits or reduced energy expenses for said consumers, without however reducing their comfort level. This point is essential to ensure successful participation of residential consumers.

2.4.2. Service sector

Measures must be taken regarding the tourism industry and public buildings through the strengthening of self-supply through renewable sources, energy efficiency and demand management. Public lighting should also be converted for greater energy efficiency and reduced light pollution. The water cycle could also be better focused on improved efficiency of pumping systems and management and control systems. And finally, the Menorca Airport, as the primary consumer of electricity on the island, must continue to work toward reduced energy demand.

According to data from Menorca's energy study, the service sector assumes 17.9% of final energy demand in Menorca, of which, electricity makes up 74.5% (47.7% of total energy consumption), while fossil fuels make up 25.5% (diesel oil and LPGs). Fossil fuel demand in this sector represents 36% of its total demand on the island, without taking into account demand from transport (land, air and maritime).

Proposals for measures for the service sector, within the context of efficiency, integral energy management and self-generation of energy from renewable sources, have been established in considering their public or private nature, as well as installation typology. This has resulted in four headings: tourism industry, public buildings, public lighting and services associated with the water cycle on the island. The economic benefits associated with the implementation of the proposed measures in turn have a positive impact on the local economy, improving Menorca's international exposure.

2.4.2.1. TOURISM INDUSTRY

Tourist activity is at present the island's principal economic driving force. In fact, human pressure during Menorca's high tourist season implies approximately two and a half times greater levels of human pressure than during low season. It is thus very important to carry out actions aimed at increased self-consumption, improved energy efficiency and better demand management such that this seasonal variation does not become a significant problem with regard to the implementation of Menorca's new energy model.

SELF-CONSUMPTION VIA RENEWABLE SOURCES

- Use of local energy sources:
  - Installation of photovoltaic generation on rooftops and car parks, as well as micro wind if possible.
  - Solar thermal systems for water heating (support for DHW, heating and heated swimming pools).
  - Biomass boilers to substitute those using diesel oil and liquefied petroleum gas (LPG).
- Develop mechanisms for seasonal compensation of self-consumption installations with grid feed-in.
- Create a specific brand for tourism-based businesses that are committed to objectives of decarbonisation.

ENERGY EFFICIENCY

- Introduce measures that promote efficient energy usage by tourists visiting the island of Menorca.
- Awareness education for sector personnel. Introduce the figure of the "energy ambassador" for hotels, as the individual responsible for observing the behaviour of personnel and how relevant processes are carried out, so as to identify simple improvements in habits that could result in direct energy savings without the need of further investment.
- Promote the renovation and modernisation of buildings' installations to improve efficiency and the use of local energy sources:
  - Systems that monitor energy consumption.
  - Heat recovery systems.
  - Climate control systems with heat pumps to replace diesel oil and LPG boilers.
- Energy management systems that show the evolution of consumption and savings made based on actions taken.
- Systems and installations that promote the use of seawater (heat exchange, etc.).
- Design a specific programme for energy efficiency and decarbonisation for the hotel industry, replicating successful examples through business associations.
- Perform energy audits for tourism establishments.
- Improve the efficiency of buildings in accordance with the measures defined for the residential sector (see section 2.4.1).

ACTIVE DEMAND MANAGEMENT

As mentioned above, the need for more flexible demand is essential for reaching higher levels of renewable integration for isolated systems. The service sector represents 47.7% of total energy consumption for end users in Menorca. Therefore, achieving the active participation of these consumers in operational activities will be fundamental to achieve the established objectives. Within the service sector, one of the principal consumers of electric energy can be found in tourist accommodations establishments, primarily hotels.

In line with previous experiences on a global level, the end uses associated with electricity demand in the tourism industry that are more flexible, or could be through the installation of thermal energy storage (PCM or similar), are climate control systems (especially centralised with heat pumps) and hot water production.

In light of these needs, it is proposed to establish in the corresponding regulations that buildings with centralised systems for climate control installation management or existing buildings that require changes to or the addition of a new centralised control system, may be securely connected to a third-party local network (Ethernet or Wi-Fi). This would allow them to receive external price signals or command actions according to the technical specifications in the OpenADR 2.0b communications protocol, as well as allowing behavioural configuration of said installations based on the signals.

Thus, centralised control systems will be able to automatically plan the functions of the equipment associated with the cited end uses, taking into account the users' habits, the selected comfort levels, previously received price signals and expected meteorological conditions. Consumers from the tourism sector can thus take part in future demand response programmes, which will imply additional benefits or reduced energy expenses for said consumers, without however reducing their level of service.

2.4.2.2. PUBLIC BUILDINGS

SELF-SUPPLY FROM RENEWABLE SOURCES

Photovoltaic installations must be incorporated into public buildings, infrastructures and surroundings, while also working toward greater energy efficiency in these facilities through the following actions:

- Perform energy audits for public installations and buildings.
- Implement a programme for information and training for energy professionals in the public sector.
- Introduce practices for the capitalisation of economic savings stemming from energy efficiency for reinvestment in further energy-saving measures.
- Improve energy efficiency and the use of local energy sources in buildings and installations from the public sector:
  - Annual programme of actions to promote energy efficiency in public buildings.
  - Improve efficiency of buildings in accordance with the actions established for the residential sector (see section 2.4.1.).

- Heat recovery systems.
- Energy consumption monitoring equipment.
- Photovoltaic installations on rooftops of buildings for self-consumption, with or without storage systems.
- Solar thermal systems for water heating.
- Biomass boilers to substitute those using diesel oil and liquefied petroleum gas (LPG).
- Climate control systems with heat pump and/or thermal energy storage systems.

ACTIVE DEMAND MANAGEMENT

Other consumers within the service sector that can be of special interest, not only as one of the primary consumers of electrical energy on the island, but also because they should serve as an example for Menorcan society, are public buildings.

In line with previous experiences on a global level, the principal end use associated with the electricity demand of public buildings that are more flexible, or could be through the installation of thermal energy storage (PCM or similar), are climate control systems (especially centralised with heat pumps).

In light of these needs, it is proposed to establish in the corresponding regulations that buildings with centralised systems for climate control installation management or existing buildings that require changes to or the addition of a new centralised control system may be securely connected to a third-party local network (Ethernet or Wi-Fi). This would allow them to receive external price signals or command actions according to the technical specifications in the OpenADR 2.0b communications protocol, as well as allowing behavioural configuration of said installations based on signals.

Thus, centralised control systems will be able to automatically plan the functions of the equipment associated with the cited end uses, taking into account the users' necessities, the selected comfort levels, previously received price signals and expected meteorological conditions. Consumers from the public sector can thus take part in future demand response programmes, which will imply additional benefits or reduced energy expenses for said consumers, and perhaps more importantly, without reducing the users' comfort level.

2.4.2.3. PUBLIC LIGHTING

Menorca already has ample experience regarding the modernisation and improvement of its public lighting thanks to actions carried out, from the beginning of this century, through the execution of the various phases of the Plan for Energy-Efficient Public Lighting in the Municipalities of Menorca (PEEM).[12] These measures received further support through the commitment made in 2016 to improve the quality of the night sky, the drafting of the Regulations for the protection of Menorca's night sky and the awarding of certification as a Starlight Reserve and Starlight Tourist Destination, received in January 2019 within the framework of the FITUR tourism trade fair.

Being a Starlight Reserve entails commitment to the protection of the night sky and the elimination of light pollution, while prioritising efficient and sustainable lighting within the island environment, improving the quality of life for local flora, fauna and residents alike. Additionally, the Starlight Tourist Destination[13] certification serves as an opportunity to invigorate a new form of sustainable tourism: astrotourism. Starlight tourist destinations are not only required to demonstrate the quality of their night sky and relevant protection measures, but also to adapt infrastructures and activities related with tourism supply (accommodation, available means of observation available to visitors, training for personnel responsible for astronomic interpretation, etc.) and its integration with nature.

To this effect, a detailed inventory of all of Menorca's outdoor public lighting has been created, so as to better evaluate the baseline scenario and establish which actions are considered as priorities with a two-fold objective: on one hand, to improve energy efficiency, and subsequently greenhouse gas emissions; and on the other, to reduce light pollution on the island and hence improve the night sky, thus offering the best possible experience in sky gazing.

The actions that are presented in this section therefore cover two goals: one on hand, they ensure the preservation of the quality of the night sky through the limitation and reduction of light pollution; and on the other, they further contribute to the island's energy decarbonisation by reducing consumption from outdoor lighting through improvements made with respect to energy efficiency and the streamlining of such lighting.

Some highlights from the actions to be carried out in this context include:

- Creation of an office for the protection of the nighttime environment.
- Implementation of the island's zoning in accordance with the Regulations for Protection of the Nighttime Environment.
- Training of specialists, designers and technicians in matters of energy efficiency and lighting technology.

[12] ***See the website of the Menorca Waste and Energy Consortium:*** **<http://cremenorca.org/Contingut.aspx?IdPub=8533&menu=Energia>**
[13] ***See the website of the Menorca Biosphere Reserve Agency:*** **<http://www.menorcabiosfera.org/Contingut.aspx?idpub=1791>**

- Development of additional phases for the PEEM, focusing on:
  - Substitution of obsolete and/or inefficient lighting systems for others with LED technology.
  - Smart public lighting control in highly seasonal tourist and residential areas.
  - Implementation of control systems that utilise sensors that allow for flow adjustment based on varying levels of human presence.
  - Reduction of lighting levels based on the actual needs of each area.
  - Streamlining of decorative lighting and projected light used on buildings and in special areas.
  - Strengthen cultural awareness, appreciation and respect for the night sky.

The ultimate goal is to reduce energy demand from outdoor lighting in Menorca by at least 40% with respect to 2017 levels.

2.4.2.4. THE WATER CYCLE

The activities that make up the water cycle are characterised as processes with highly flexible consumption that can be utilised to transfer consumption from times with little renewable resource availability to times in which there is a surplus of said energy, thus facilitating the integration of renewable generation into the electric power system.

In general terms, the execution of an energy study on said installations would be a necessity so as to distinguish their energy consumption, identify possible points for improvement from an energy efficiency and maintenance perspective, determine the feasibility of renewable generation integration, and study the current flexibility of said process and the technical-economic viability of improving flexibility.

A majority of the water used on the island stems from collection from groundwater pumping, with a maximum allowed volume of 37.8 hm^3/year, a figure that if reached, would seriously harm the integrity of the aquifers, as their natural rate of refilling from rainwater is approximately 49 hm^3/year. The resulting reduction in outflow volume would result in saltwater intrusion (source: Es Migjorn Aquifer Water Balance, J. A. Fayas, 2014). The water balance is therefore quite delicate and is conditioned by seasonal changes and periods of drought.

Urban water supply (10 hm^3/year), especially during tourist season with a substantial increase in water demand, and agriculture (9 hm^3/year) can be attributed with 91% of the total volume of authorised extraction.

The strategy will hence focus primarily on urban water supply, with an integrated approach on the entire water cycle, and on the agricultural sector, where efforts will be made both with respect to activity adaptation toward reduced water demand, as well as the improved efficiency of the resource's collection and utilisation. This will be done without ignoring that efforts must also be made with respect to the harnessing of treated wastewater (with improved tertiary treatment for agricultural uses) and mainstreaming rainwater collection in urban environments for the direct use of non-potable water.

Below is a brief description of the existing installations and the potential courses of action for the different types of systems that make up Menorca's water cycle.

CLEAN WATER PUMPING SYSTEMS

The clean water pumping system is well distributed across the entire island, although, as is logical, the network grows denser near population centres. This system is the property of the different municipalities, although its maintenance and exploitation is in certain cases awarded to private entities through corresponding public tenders.

The proposed actions for these installations focus on improved efficiency in the pumping systems, with the consequent reduction in electricity demand associated with these, as well as improved demand flexibility.

To achieve the established goals, proposals include the installation of variable speed controllers in booster pumps, which would allow for improved efficiency thanks to the reduction of the effects of oversizing achieved in calculating these systems and the more accurate adjustment of their power demand to the existing demand at any given moment. This will also help achieve greater adjustment flexibility, which along with the increased water storage capacity from the installation of additional tanks, will allow for greater demand flexibility associated with the process. The installation of additional storage tanks will be evaluated from a techno-economic perspective as part of the energy studies proposed in this point.

Although from an energy efficiency point of view the installation of a simple control system to reduce consumption would suffice, to achieve the benefits of this new flexible resource from a management demand perspective, its management must be carried out through a centralised control system that possesses sufficient data for the operational optimisation of the group of pumping installations based on the priority criteria expected at any given moment. This system must have the ability to receive price and consumption variation signals according to a specific communications protocol (OpenADR 2.0 is proposed) such that other professionals in the electric power system, or demand aggregator or grid operator, can send signals that condition the operation of the installations in accordance with foreseen or existent grid conditions at any given time.

WASTEWATER TREATMENT PLANT (WWTP)

Menorca's wastewater treatment system is made up of 12 plants located near the principal city centres. Currently, the operation and maintenance of these installations is managed by the company ABAQUA, through a concession contract.

As has been verified through various studies on a global scale, (EU-DEEP project, for example), this type of installation accommodates highly flexible consumption processes that could help to improve grid operations. In principle, and based on prior experiences, it would be advisable to act on the water collection line and the sludge line, although it is likely that during the energy study other measures for action may also be considered.

With regard to the water collection line, the interruption or a reduction in speed is proposed for the pumping station associated with water transported to the treatment plant. More precisely, the tank located at the plant's entrance, which is normally used for water storage during periods of rain, can be used to store water during periods with surplus renewable generation and hence halt pumping at times of renewable shortage. To execute this measure, it may be necessary to install variable speed controllers on pumps and integrate the management of these devices within the plant's control system.

Conversely, the sludge line can have a typical duration of 10 to 13 hours, and thus daily planning is proposed for this process based on the needs of the supply network and the availability of renewable resources. To do so, it will be necessary to ensure that the process's monitoring and control system allows for this type of measures. Otherwise, the relevant modifications will be made to the system to revert the situation.

As is the case for clean water pumping systems, it is necessary for the control system for treatment plants to be able to receive a prevision of prices or the network situation so as to implement the corresponding daily planning. Proposed for this purpose is the use of a communications protocol used in such applications like OpenADR, through the use of libraries that can be installed in current control systems of through a communications gateway if this type of modification should not be admitted.

CIUTADELLA DESALINISATION PLANT

Desalinisation plants are normally used to supply drinking water to areas where the provision of this resource is difficult, and are likely the most common application on islands, where sources of this resource can be scarce. In fact, there are a total of 17 desalinisation plants found in the Balearic Islands, and 19 located in the Canary Islands.

In Menorca, there is only one reverse osmosis desalinisation plant, located beside the Ciutadella Sur treatment centre, and has been operational since 2019. This plant is designed to supply a daily volume of 10,000 cubic metres through the two processing lines of 5,000 cubic metres each, although there are plans for expansion to 15,000 cubic metres per day.

The purified water from this treatment plant is used to satisfy the water demands of the municipality of Ciutadella. The desalinisation plant is operated and maintained by ABAQUA through a concession contract.

Desalinisation is a process that consumes great amounts of energy and can be made quite flexible without the need for significant investment. Proposals include the utilisation of existing tanks, or an increase if necessary, so as to store water from the desalinator, such that energy demand can be managed by the pumping systems associated with the different tanks. In some cases, it may be necessary to install variable speed controllers on pumps to allow for more accurate adjustment. The treatment plant has a centralised monitoring and control system, which may require slight modifications to incorporate the proposed measures, as well as the addition of functions to receive prices or information regarding the state of the grid.

Yet another proposal involves the implementation of renewable generation of photovoltaic and wind origin so as to reduce the installation's electricity demand, reducing the specific costs for its associated energy supply and helping to achieve a sustainable energy system.

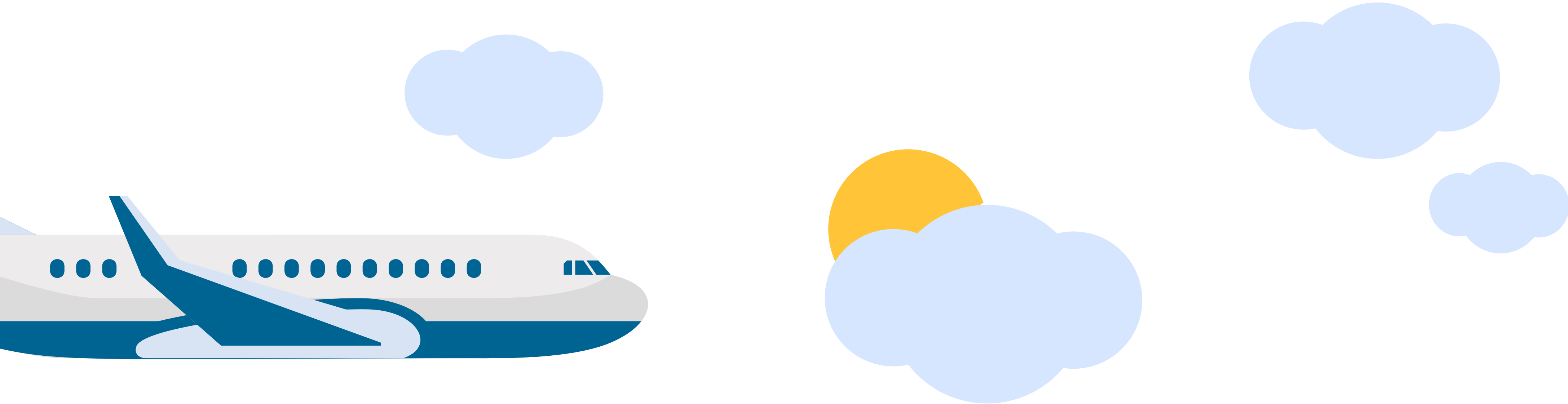
OTHER MEASURES TO BE EXECUTED

- Carry out a comprehensive audit of the water cycle's energy consumption.
- Design and implement improvements to the installations and their maintenance, including:

  - ☑ Installation of variable speed controllers to improve the efficiency of pumping systems in the distribution grid and provide greater flexibility of adjustment.
  - ☑ Promotion of energy self-consumption for the water cycle, introducing photovoltaic solar and wind energy, both for energy collection and distribution, as well as water treatment (waste-water, denitrification and desalinisation).
  - ☑ Improvement of tertiary treatments at the Maó-Es Castell WWTP for reuse in agricultural and industrial uses.
  - ☑ Experimental aquifer recharge project with purified water from the Sant Lluís WWTP.
  - ☑ Promotion of the installation of smart meters for all collection systems.
  - ☑ Incentives for the utilisation of rainwater in new constructions through the modification of municipal ordinances.
  - ☑ Demonstrative project for large-scale water collection at the Menorca Airport for urban and agricultural uses.
  - ☑ Recovery of public cisterns.
  - ☑ Promotion of green filters for wastewater treatment in independent houses in non-urban areas.

2.4.2.5. MENORCA AIRPORT

The Menorca Airport is located 4.5 km from the city centre of Maó. In 2016, 3.2 million passengers made use of its installations, with this figure increasing by around 5.7% over the last four years, with 89% of this traffic concentrated in the island's high season (April to October). The principal infrastructures and installations include: 1 terminal, 1 Cat I runway, 42 check-in counters, 6 baggage carousels, 16 boarding gates, 5 jet bridges, 1,948 parking spaces, 7 restaurants and cafés and 11 duty free shops.



In terms of energy demand, the Menorca Airport is the largest consumer of electricity on the island, with a total annual consumption of 10.84 GWh in 2017. The terminal building consumes around 73% of the total electricity demand, with the HVAC (Heating, Ventilation and Air Conditioning)[14] system representing 41% of the building's total demand.

The Airport has installed a 75-kW photovoltaic system in one of the two main parking areas. Energy consumption of a majority of the end uses is monitored by a group of approximately 20 meters. The HVAC system's hot/cold production is made up of two heat pumps that are controlled by a local centralised Supervisory Control and Data Acquisition (SCADA) system. This system also monitors and controls the lighting system and other existing installations at the Airport.

There are two emergency diesel generators with support from certain UPSs[15] to ensure electricity supply for at least the Airport's vital electricity needs. Currently, the operator of Menorca's system has requested the use of these engine-generators during peak summer periods. This option could be useful to reduce peak demand, which typically occurs for less than 300 hours per year, instead of increasing the island's generation capacity.

SELF-CONSUMPTION FROM RENEWABLE SOURCES

The Airport already buys renewable energy with guarantees of origin. More specifically, in 2018 40% of the Airport's electrical energy stemmed from renewable sources. This percentage increased to 60% in 2019 and is expected to reach 80% in the year 2030.

[14] Climate control system: HVAC (Heating, Ventilation and Air Conditioning).
[15] UPS engine-generators (Uninterruptible Power Supply).


CEPSA

At present, the Airport makes use of photovoltaic generation, although there are plans for the installation of another 459 kWp photovoltaic plant in the carports of the public parking lot.

The system could be complemented by a hybrid battery group, which would be linked to photovoltaic solar plants: on one hand, the fast response battery system (e.g. lithium-ion) with 60 kW of installed power and a total energy capacity of 120 kWh; and on the other, a slow response battery system (e.g., lead-acid) with 60 kW of installed power and a total energy capacity of 480 kWh. Renewable energy production could feed either the Airport's electrical demand or the installed batteries.

ENERGY EFFICIENCY

Efforts are currently being made at the Airport regarding awareness of energy consumption management and its control and monitoring.

Meters must be installed to remotely monitor total consumption, the HVAC system (at two measurement points), the storage systems and renewable energy generation.

One interesting project that could improve overall energy efficiency (not just at the Airport, but across the entire community) involves large-scale water collection on the airport's premises for urban and agricultural uses. Collection is estimated at approximately 1 hm^3 per year, which is taken at present from groundwater, with approximate electricity consumption for final distribution of 1 kWh/m^3.

Yet another action for energy efficiency at the Airport involves the mass-installation of efficient lighting systems for the Airport's indoor and outdoor areas and runway and apron lighting beacons and towers. Also projected is the installation of solar protection coatings on the terminal's façade so as to reduce consumption for climate control.

ACTIVE DEMAND MANAGEMENT

Proposed is the installation of a heat storage system that utilises PCM (Phase Change Material) to increase the flexibility of the HVAC system's hot/cold production. This system will allow customers to charge much of their energy consumption from periods of greater to lesser demand, or simply to provide a certain degree of flexibility to the energy system.

EV charging points can also be installed in two areas of the Airport's existing car parks. These units would allow for fast and slow charging and remote charging management. The EV charging station would incorporate its own metering system.

To reduce the emissions of third parties (baggage handling systems, passenger and employee vehicles, etc.), the Airport is to carry out the following initiatives:

- **Installation of charging points in car parks:** The initial phase, for 2020, foresees the installation of 3 charging points for electric vehicles in the airport's parking area.

- **Reduction in emissions from baggage handling systems:** For the gradual reduction of emissions from GSE (Ground Support Equipment) teams, the documentation that stipulates conditions for the licensing of baggage handling activities now requires commitment to a 20% reduction in emissions for 2020. On this basis, the baggage handling entities have drafted a plan for emissions reductions and have established a common methodology for calculating vehicle emissions.

2.4.3. Industrial sector

Business parks will be created with energy self-consumption from renewable integration, shared self-consumption systems and energy storage. Industrial consumers would reduce their energy costs while increasing competitiveness. Additionally, the advancement in the purchase and sale of renewable energy will serve to foster interest for self-consumption in this sector.

According to data from Menorca's energy study, the industrial sector assumes 3.5% of the island's final energy demand, of which, electricity makes up 43.8% (5.5% of total energy consumption), while fossil fuels make up 56.1% (natural gas, diesel oil and LPGs). Fossil fuel demand in this sector represents 15% of its total demand on the island, without taking into account demand from transport (land, air and maritime).

Despite the fact that Menorca is not home to substantial industrial activity, business parks (made up primarily of industrial units) represent an interesting opportunity for the integration of generation from renewable sources. Also, the spread of the proposed activities from the tourism industry to this sector (demand management and energy efficiency) could result in increased competitiveness, along with the consequent reduction in electricity consumption and fossil fuel dependence.

SELF-CONSUMPTION FROM RENEWABLE SOURCES

The existence of large shadeless areas, together with processes of elevated energy consumption result in a clear opportunity for the integration of renewable generation in business parks in the form of self-consumption. In this context, one proposal involves the promotion of individual self-consumption for industrial consumers of these characteristics, which would allow for a reduction in their dependence on electrical energy, subsequently reducing energy costs and increasing competitiveness.

The compensation mechanisms for grid feed-in during periods in which generation is greater than demand will serve to considerably increase interest in self-consumption with industrial consumers.

Actions to be taken in this regard include:

- Integration of renewable generation (photovoltaic and wind) in business parks.
- Advancement of individual or shared self-consumption for business parks around the island, or for different sectors of these.
- Development of Power Purchase Agreement (PPA) formulas for the purchase and sale of renewable energy in the business sector.
- Small and mid-scale storage installations.
- Financing strategies for energy-related improvements.
- Installation of biomass boilers for businesses to replace diesel oil and liquefied petroleum gas (LPG).
- Demonstrative pilot projects.

ENERGY EFFICIENCY

As is the case in other sectors, efforts will be made to improve energy efficiency in production processes for industrial consumers, especially those measures that reduce dependence on fossil fuels through the exploitation of residual heat from operations and the reduction of losses, for which it will be necessary to create financing strategies, in addition to those that already exist, from the Institute for Diversification and Saving of Energy (IDAE). Proposals include, on one hand, to reduce specific energy consumption in existing industries, and on the other, to increase competitiveness thanks to decreased energy costs. In this sense, improvements to envelopes must be carried out and opportunities offered for installations on rooftops.

ACTIVE DEMAND MANAGEMENT

The introduction of demand management in Menorca's industrial sector requires the execution of specific studies and demonstrative pilot projects in those centres considered references within the island's industrial activities. This process will include the evaluation and validation of strategies for action in the analysed sectors, so as to reduce demand and increase flexibility. This will allow consumers from the industrial sector to take part in future energy response programmes, which would result in further benefits or reduced energy costs for these consumers, without affecting the quality of their products.

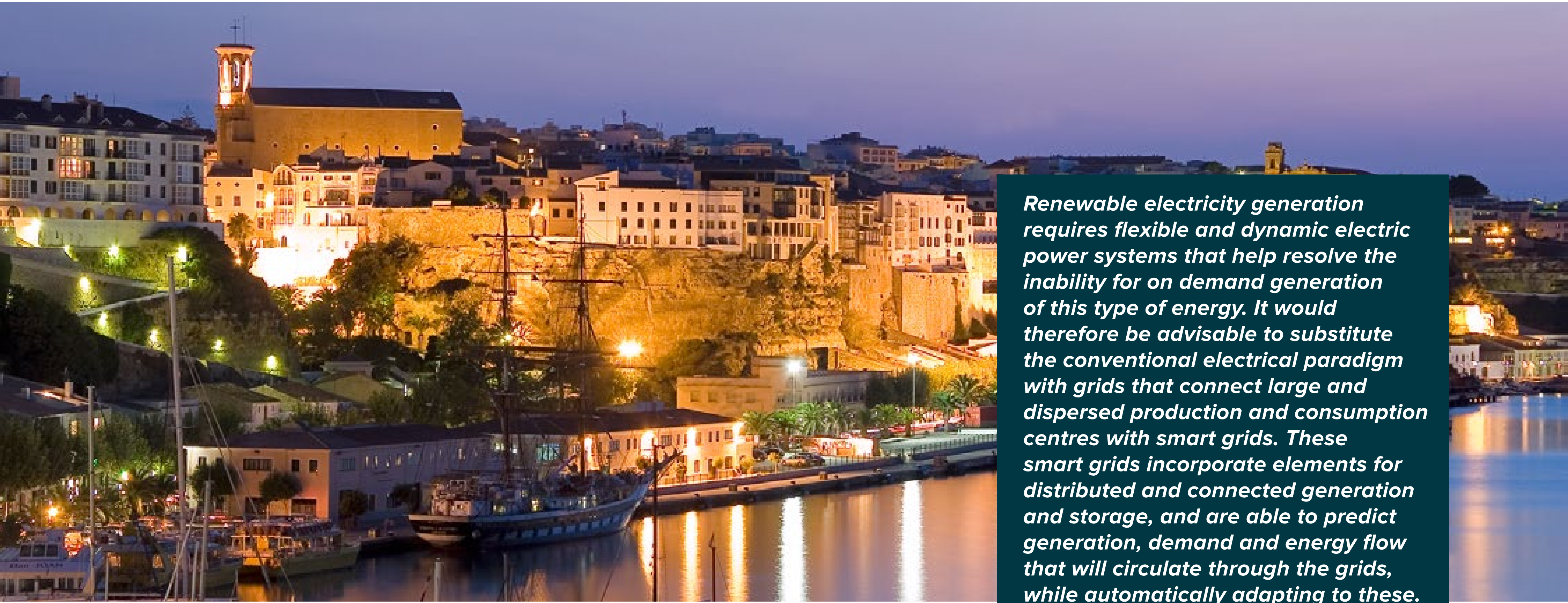
2.4.4. Primary sector

Necessary steps include the financing of machinery replacement, especially regarding the substitution of diesel oil as an energy source, so as to reduce pollutant effects while also serving to improve competitiveness of the sector's production.

According to data from Menorca's energy study, the primary sector assumes 2.9% of the island's final energy demand, of which, electricity makes up only 16.6% (1.7% of total electrical energy consumption), while fossil fuels make up 83.4% (red diesel). Fossil fuel consumption in this sector makes up 19% of the total demand of this type on the island, without taking into account demand from transport (land, air and maritime).

Although the primary sector is not one of the most demanding in terms of energy demand, it is however noteworthy that it is one of the economic activities with the greatest dependence on fossil fuels, primarily red diesel. In this context, it has become necessary to finance the replacement of machinery in the primary sector, especially for those cases in which red diesel can be replaced by a less pollutant energy source (electricity, LNG, biomass, etc.). The goal of these measures, apart from a reduction in emissions, is the improved competitiveness of products from the sector.

2.5. SMART GRIDS



Renewable electricity generation requires flexible and dynamic electric power systems that help resolve the inability for on demand generation of this type of energy. It would therefore be advisable to substitute the conventional electrical paradigm with grids that connect large and dispersed production and consumption centres with smart grids. These smart grids incorporate elements for distributed and connected generation and storage, and are able to predict generation, demand and energy flow that will circulate through the grids, while automatically adapting to these.

Due to the inability to generate renewable electrical energy on demand (i.e., whenever and wherever it is needed), the fundamental issue to allow for the penetration of such energy involves making distribution and transmission grids dynamic, so these can efficiently adapt to the behaviour and activity of all users connected to them. Users, in this sense, include both consumers and producers of energy. Figure 25 shows the difference between conventional grids and smart grids.

Conventional grids are characterised by large energy production plants that are typically set away from the main consumption centres, large transmission systems (extra-high tension) to connect large production and consumption centres, and an extensive distribution network, made up only of passive elements such as low and medium voltage lines, transformers and passive consumers. Electric power production in these conventional systems is based on sizable thermal units (normally utilising fossil fuels).

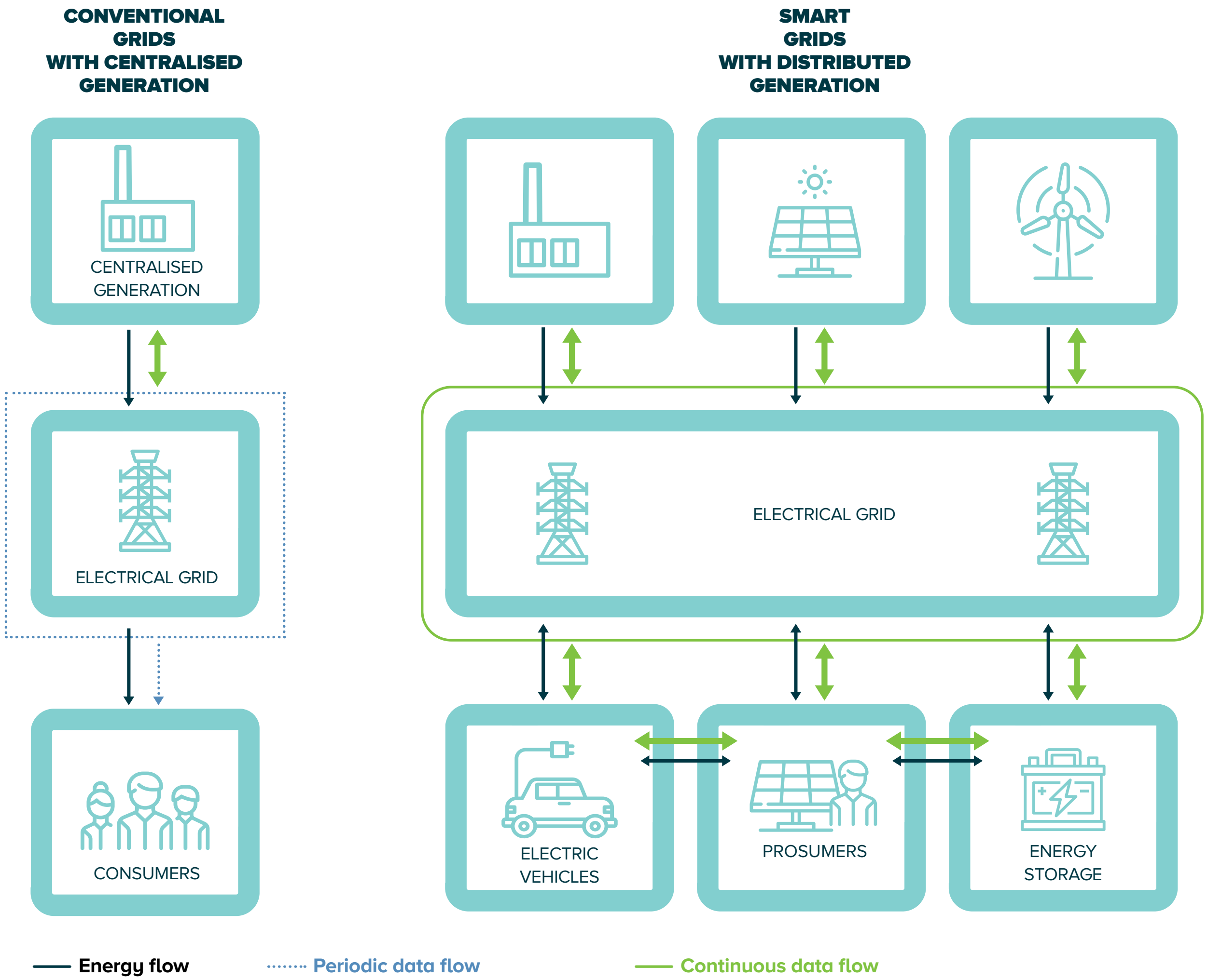


Figure 25. Conventional grids with centralised generation versus smart grids with distributed generation.

This conventional paradigm is being substituted by smart grids, which aim to generate electricity using the maximum renewable energies possible, primarily photovoltaic solar and wind. These are advantageous in that their generation is not harmful to the environment, although on the contrary, they are inconvenient in that the primary energy source is not always available, resulting in intermittent, and often unpredictable, production.

This is resulting in a complete transforming of the conventional electrical paradigm, which is constantly evolving toward the smart grid concept. This involves much more flexible and dynamic electric power systems that incorporate elements for distributed generation and storage connected by smart grids that can predict generation, demand and energy flow that will circulate through the grids, while automatically adapting to these.

The implementation of smart grids requires the combined use of a set of technologies that make them possible, such as advanced generation and consumption technologies, a series of low and medium-voltage networks that can withstand alterations, management and control centres, information and communication technologies, advanced power electronics devices, dispatch centres that allow for short and medium-term negotiation of retail energy transactions and subsidiary services, etc.

The principal characteristics required of such smart grids include:

- **Reliability.** With levels similar or superior to conventional supply grids. It is also possible to take advantage of their capability to automatically readjust themselves when faced with malfunctions in any of their elements, hence minimising blackouts (self-healing).
- **Interactivity.** Such that users can interact with information, market and power exchange platforms (smart markets).
- **Predictability.** Instead of being reactive like conventional grids, they can foresee emergencies and remain prepared and take action if these should arise.
- **Interconnectivity**. Grids must be able to connect areas distributed over extensive areas and interact with other smart grids or other types of grids.
- **Security.** Take on and coordinate data surveillance, control, maintenance, marketing and technology.

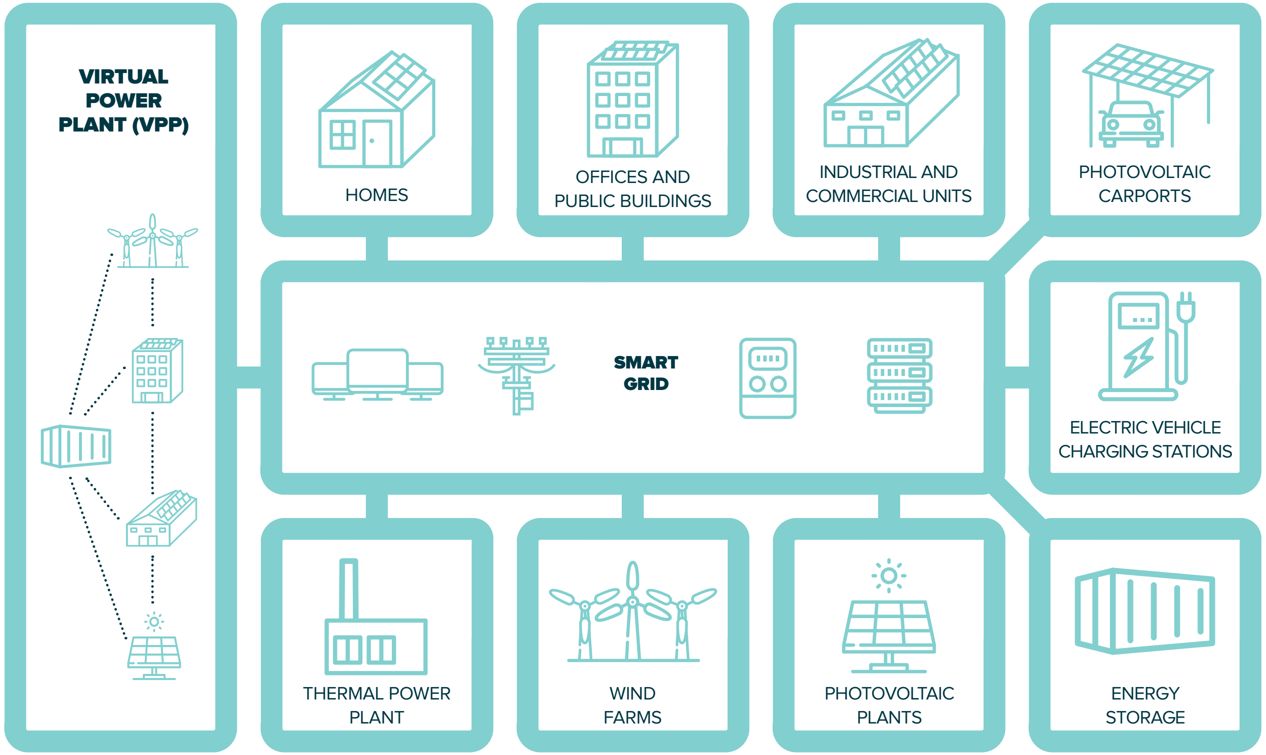


Figure 26. Physical and virtual elements of a smart grid.

Figure 27 shows the ICT structure and control centres necessary to ensure the grid's operation, distinguishing between actions of a purely controlling nature and transactions made between buying and selling agents that guarantee that the grid operator has sufficient resources to ensure any and all energy transactions.

In 2018, a severe storm caused serious complications to Menorca's electric power supply, leaving much of the population without electricity supply for two or three days. The consequences of this situation were even more drastic due to the previously damaged cable that connected the island with Mallorca. This type of scenario makes it clear that the island's supply system would benefit from the advantages provided by smart grids.

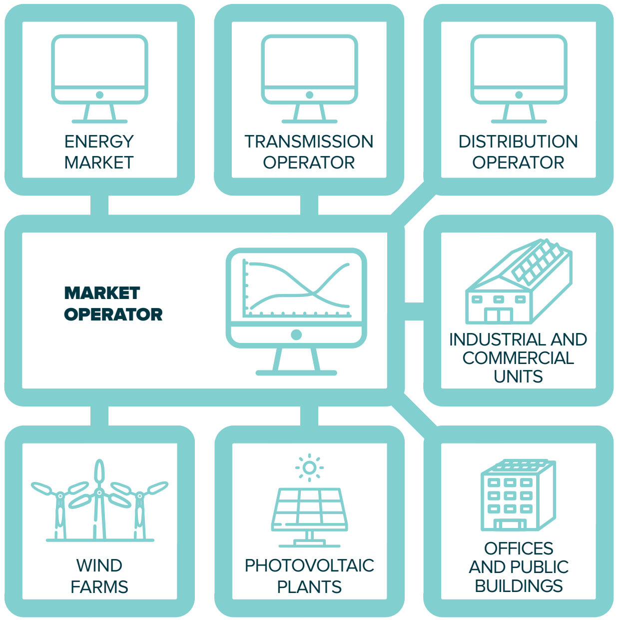


Figure 27. Data exchange and control on a smart grid.

2.5.1. Current transmission and distribution infrastructure in Menorca

Menorca's electric power system is made up of a transmission network with six 132 kV lines, three electrical substations that reduce voltage to 15 kV, and another that increases the output voltage of the thermal power plant and medium-voltage lines that supply, with a radial operation configuration, electric power to the different areas of consumption. The following section explains the configuration of the electricity transmission and distribution infrastructure on the island to contextualise those improvements that are planned through the implementation of this strategy.

In line with its conventional structure, Menorca's insular electric power system is made up of a transmission network with six 132 kV lines, organised into two virtually parallel circuits:

- Maó-Dragonera I
- Maó-Dragonera II
- Ciutadella-Dragonera
- Ciutadella-Es Mercadal
- Es Mercadal-Dragonera
- Interconnection with Mallorca

With the exception of the connection with Mallorca, the entire transmission network is duplicated so as to increase the system's reliability and hence provide alternate supply in case of unavailability of any of the lines. The map of the overhead transmission lines is shown in figure 28.

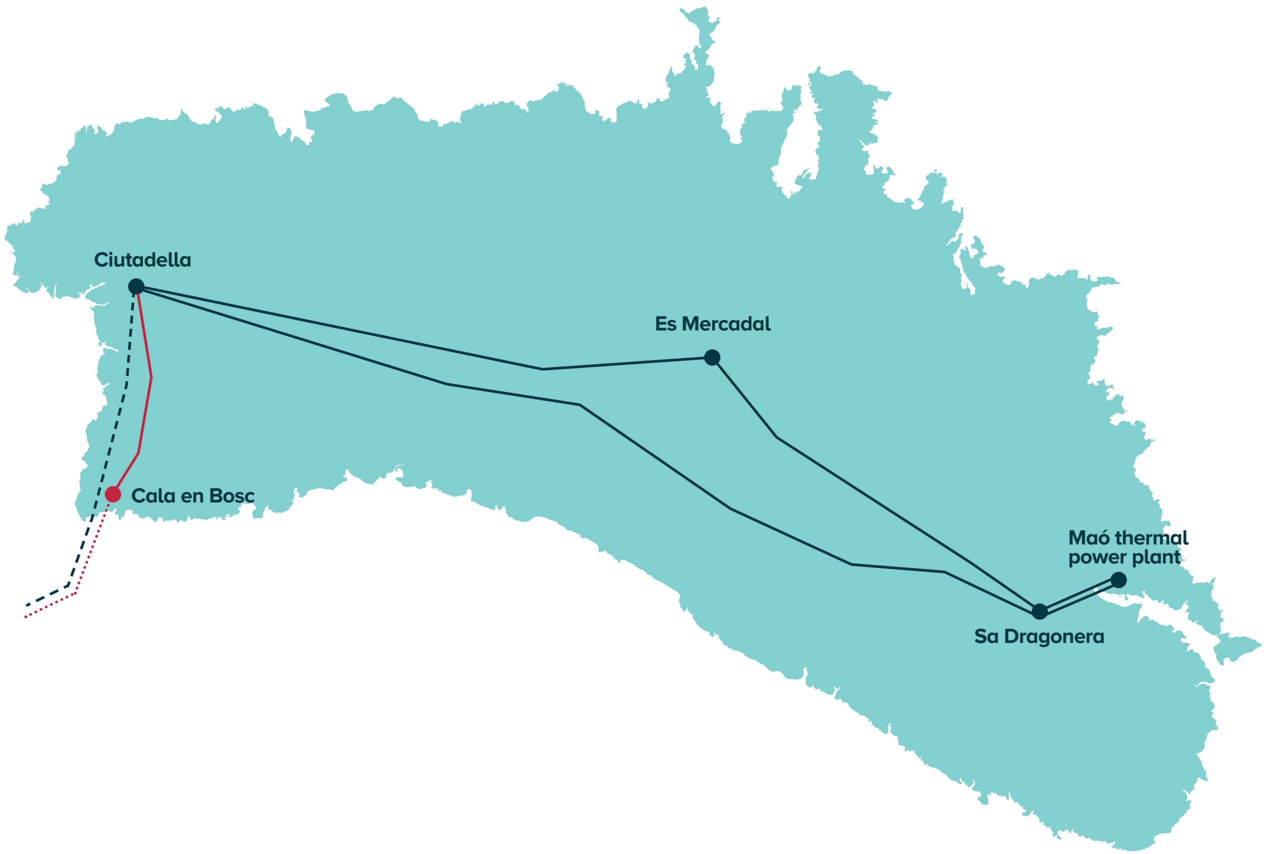


Figure 28. Electricity transmission network in Menorca.

The transmission network currently has five electrical substations:

1. **Dragonera, Es Mercadal, Ciutadella**:
   all interconnected and with 132 kV/15 kV transformers to supply the medium-voltage distribution lines. The installed power in these three substations is as follows:
   - Dragonera has three 30 MVA transformers, with another transformer put into operation in 2019.
   - Es Mercadal is made up of four 30 MVA transformers.
   - Ciutadella has three 30 MVA transformers.

2. **Maó thermal power plant:** connects production from the thermal power plant with the overhead transmission network.

3. **Cala en Bosch (inoperative):** connected the former undersea cable with the overhead transmission network.

Expansion work is being done on the Ciutadella substation for connection with the undersea cable that is under construction.

DISTRIBUTION LINES

Distribution in Menorca is carried out through medium-voltage lines (15 kV) that supply, with a radial operation configuration, electric energy to the various areas of consumption via the three existing substations.

Described below are the characteristics of these three substations:

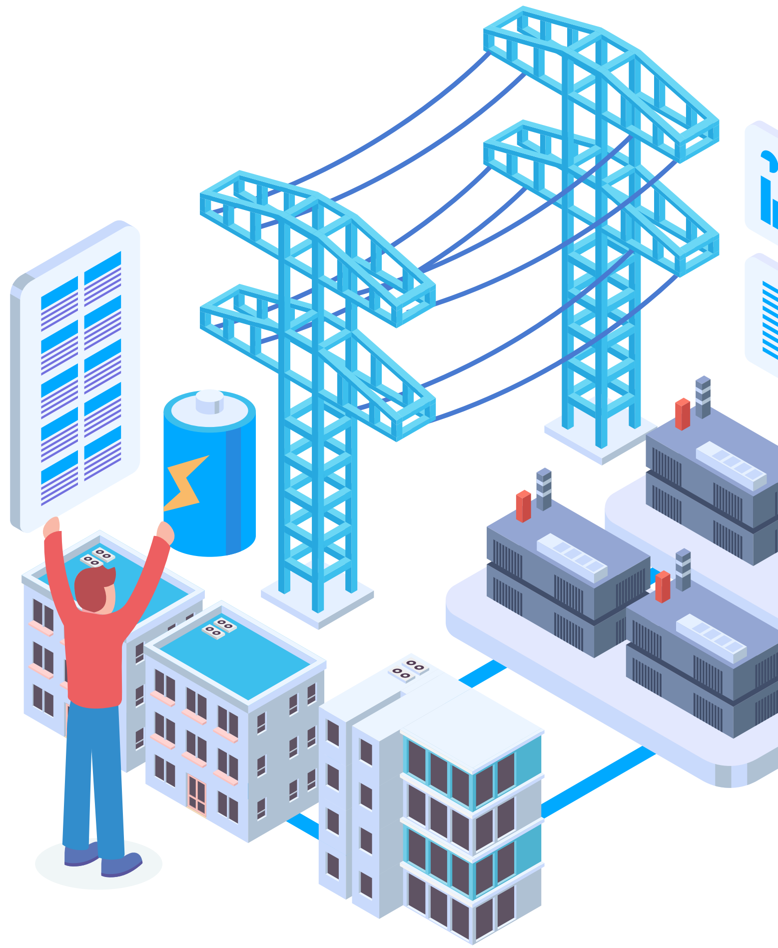
1. Dragonera has 21 medium-voltage lines with 156 MVA of installed power that supply 31,200 customers.
2. Es Mercadal has 11 medium-voltage lines with 388 transformer substations and 92 MVA of installed power that supply 17,100 customers.
3. Ciutadella has 18 medium-voltage lines with 343 transformer substations and 104 MVA of installed power that supply 21,030 customers.

These lines reach the transformer stations to achieve low-voltage common usage distribution (400/230 V). The oldest remaining distribution lines left in Menorca are from the late 1960s, while most date to the 1980s.

A majority of the existing MV distribution lines, and that can intervene in renewable penetration, are overhead. These lines include protection against homopolar faults and overcurrent at their heads (at the substation's outgoing circuit-breakers).

At present, no 15 kV distribution lines reach saturation levels of 90%, nor do the transformers at the substations. As for the low-voltage distribution transformers, there is no data available regarding their saturation level. Saturation of installations in Menorca therefore does not currently present a very serious problem. What is in fact a problem is the lack of a meshed grid due, in part, to the island's very morphology.

With respect to under-frequency protection, it is relevant that with the operational connection with Mallorca there are five load-shedding steps at 0.5 Hz intervals, where the first load shed starts when the frequency declines to 49.5 Hz. Additionally, when the connection with Mallorca is inoperative, there are eleven load-shedding steps at 0.1 Hz intervals, with the first starting when the frequency dips to 49 Hz.



2.5.2. Structural upgrades to the current networks

The introduction of renewables into Menorca's power grid will require the meshing and reinforcement of its distribution lines, hence improving the system's resilience and allowing for demand absorption.

The adaption of power grids for generation with renewable energies requires upgrades to be made to their distribution networks, especially regarding allowing for meshing.

Menorca's morphology makes meshing quite complicated for certain distribution lines, if not done through the installation of underground lines along existing roads or, in some cases, along sections of the Camí de Cavalls trail. Examples of this can be found in Fornells, Es Grau, La Mola and Cala Morell.

This would thus improve the resilience of the electric power system, and subsequently, the quality and security of supply, allowing for dual power supply, as well as easy and secure connections to renewable plants. At present, both the Son Salomó photovoltaic plant and the Milà wind farm are connected at the end of medium-voltage lines, without the option of resupply in case of unavailability.

In addition to meshing, it will also be necessary to reinforce the lines affected by the installation of renewable plants so as to absorb demand, as well as the switchgear of the transformer substations to allow for the installation of remote controls.

To better plan for the needed improvements, a coordination group should be formed, in which the distribution and transmission grid operators would take part, in addition to the Balearic Islands Government and the Island Council of Menorca.

2.5.3. Evolution of smart grids

In an electric power system, supply is provided through electrical transmission and distribution networks, which are owned by transmission and distribution operators. When consumers absorb energy, producers must supply that amount of energy to the grid. Virtual power plants (VPP) and aggregators are responsible for grouping distributed generation or demand into significant values for the system as a whole. Finally, energy retailers providers emerge as an intermediary for the sale of energy between consumers and producers of electricity. Each of these stakeholders carries out specific functions within a smart grid.

The ultimate goal of the electric power system is to supply electrical energy to final consumers with the necessary conditions of security and quality, and at a reasonable price. With this basic concept as the foundation, the emergence of various stakeholders occurs in the case of smart grids as a necessity, adding to the technical requirements an economic viewpoint to thus make it as profitable as possible.

The electrical grid is the physical medium through which consumers can obtain the electrical energy they require. Based on the type of grid (characterised, among other parameters, by voltage level and capacity), there are certain transmission and distribution networks. Distribution networks are structures that depart from the transmission network, carrying electrical supply directly to end-users. The owners of the grid, who are responsible for its maintenance and operation, are therefore the transmission and distribution companies.

If consumers absorb energy from the grid, another agent must feed that same amount of energy into the power grid, plus any losses that will always occur with any medium of energy transmission. Energy producers are hence defined as subsidiary to consumers.

In addition to consumers, producers, network owners and grid operators, other figures also exist that stem from relationships that can be established based on their size and characteristics, as well the configurations that the grid can adopt. This is the case for virtual power plants (VPPs) and aggregators, whose mission is to transform smaller distributed generation or demand resources into larger bundles that can provide significant value to the system as a whole. Finally, we have the figure of the energy retailers, as an intermediary between final consumers (small amounts of energy) and the mechanisms of the wholesale electricity production market (large amounts of energy).

The proposed competitive retail market structure requires the prior existence of mechanisms for the purchase of energy on a wholesale level (whether through bilateral contracts or any other mechanism) for there to be a reference price for the value of energy at all times that is directly correlated to its cost for energy retailers.

Detailed below are the various necessary stakeholders and activities that will form part of the smart grid that is foreseen in Menorca within the new framework that is offered by such systems.

2.5.4. Electricity sector stakeholders in smart grids

The evolution from a conventional system to a system based on smart grids and markets requires the emergence of new stakeholders and the redefinition of the functions of conventional stakeholders. In this context, there is a newly proposed structure of stakeholders and functions that would be necessary to apply the smart-grid paradigm on the island of Menorca.

CONSUMERS

Consumers are the key element of the smart grid, as the stakeholders connected to the grid that consume electrical energy, and who will also eventually take part in energy generation. Consumers are typically connected to the distribution network, although there are also large industrial consumers who can be connected directly to the transmission network.

Depending on the supply voltage to which they are connected, three types of consumers can be defined:

- **Consumers connected to low voltage** (voltage below 1000 V). These account for a majority of consumers, who most typically belong to the residential or business sectors. Small industries can also be part of this group. All consumers supplied at this voltage level are connected to the distribution network.

- **Medium voltage consumers** (between 1000 V and 30 kV) who are connected to the distribution network. This group includes a majority of industrial consumers and medium and large business consumers.

- **Consumers connected directly to high voltage** (over 132 kV). This group is made up of large industrial consumers.

If the main role of consumers is that of energy absorption from the grid, it is also possible (and ever more common) that they also have some type of energy generation device, especially involving renewable energy sources, as is described in this plan. In this case, consumers would have the option of producing some of the energy for their own demand as self-consumption (with or without compensation or sale of surplus generation) or even generate energy to directly feed power into the grid, which will depend on the size and characteristics of the generation devices available.

One final role that could be played by consumers involves providing services for system operations, which would consist of the ability to fully or partially manage the amount of energy demanded from the grid. This capability could be quite significant when related to consumers who possess energy storage devices or for electric vehicle charging. By utilising such mechanisms, in addition to other consumptions that could be managed, the consumer can dynamically offer to other stakeholders variations to their habitual consumption patterns, which would be highly beneficial for operation of the electric power system.

Consumers could provide demand response services to energy retailers, virtual power plants, distribution operators and transmission operators, albeit they could only provide services to one of these agents at a time.

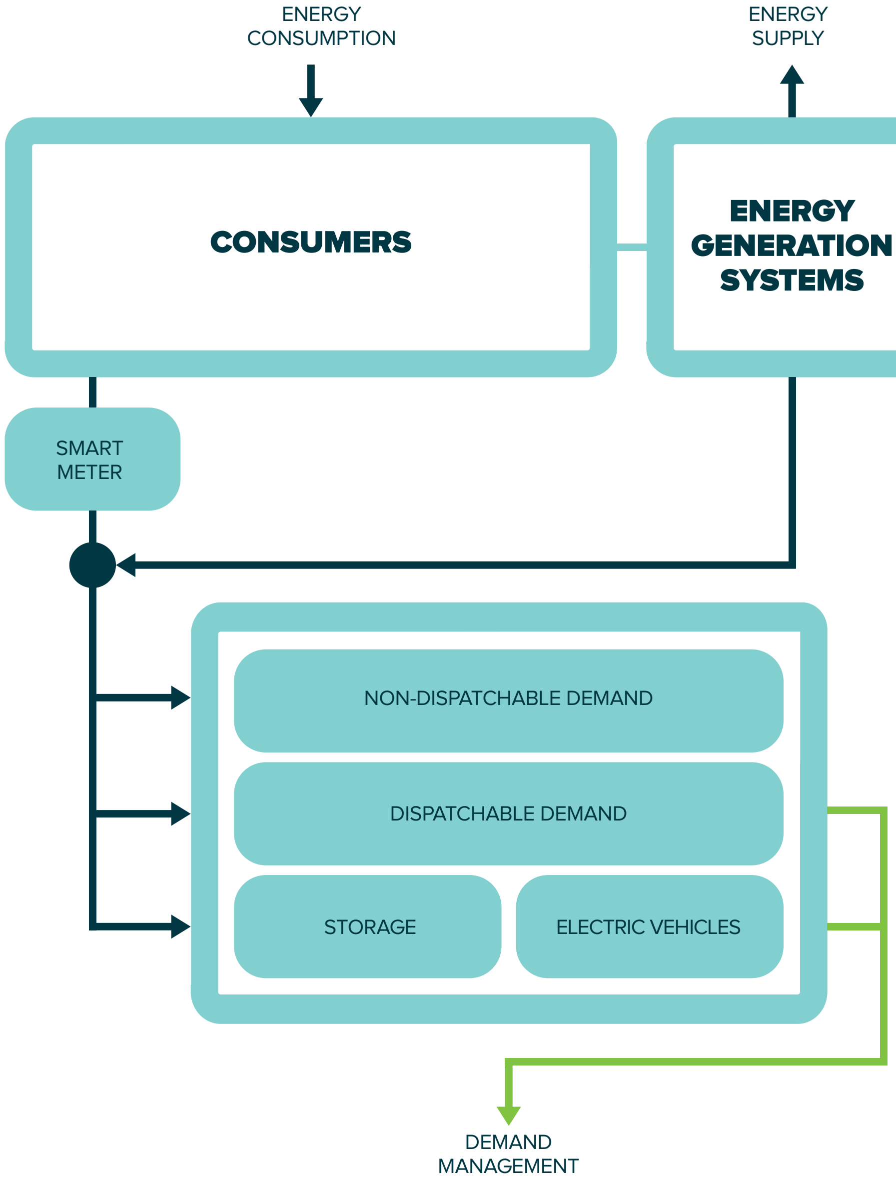


Figure 29. Consumer activity.

GENERATORS

Generators produce and supply the system with electric energy. Traditionally, large generation plants connected to the transmission network have supplied the required power to consumers in the electric power system. In Menorca's particular case, it has been supplied by the 256 MW plant in Maó. Over recent years, however, small distributed power generation sources (generally supplied with renewable energy sources) connected to the distribution network have strengthened the concept of distributed generation as a way of reducing transmission losses, as they are located in closer proximity with locations where consumption occurs. This is in fact the case for Menorca, with its current 5.1 MW of photovoltaic solar power and 3.2 MW provided by wind farms.

Regarding the nature of the raw materials used, power generators can be divided into two groups:

- **Conventional generators**, which include as their primary sources a variety of fossil fuels (natural gas, coal, fuel-oil, etc.). Due to their historical significance and the amount of power they can supply, large hydroelectric power plants (with power output of over 30 MW) are also classified in this group.

- **Renewable generators** are those that use a renewable resource as their primary source. In this context, we have wind, photovoltaic, mini-hydro and biomass generators, etc.

Generators can feed energy into the grid through essentially two methods:

- **Connected directly to the transmission network**, with the capability for sufficient control and adjustment to ensure operation under the required conditions of security and reliability. These generators must have a deliverable power capacity (P_{gen}) of at least 0.5 MW.

- **Connected to the distribution network** but managed by entities that provide the necessary size, control and adjustment characteristics to supply that power (P_{gen}) to the system. The following situations may exist:

  - Energy generators of up to 10 kW associated with consumption installations will be managed by retail energy companies that provide energy to said consumers as self-consumption.

  - Energy generators that produce over 100 kW will be managed by virtual power plants.

  - For those generators between 10 and 100 kW, they will have the option of managing their capacity through aggregators (which, in turn, sell this capacity to VPPs in larger blocks of energy) or as self-consumption via contracts with energy retailers.

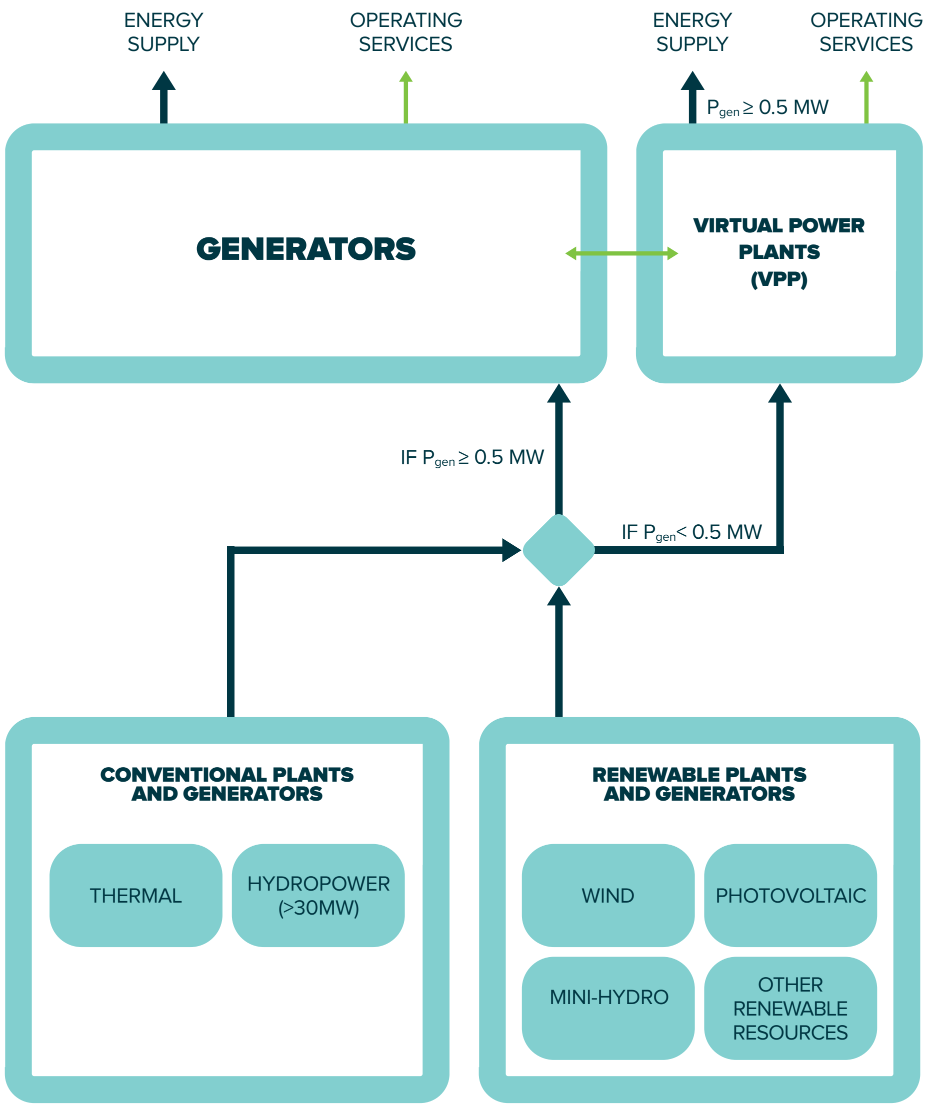


Figure 30. Generator activity.

In addition to supplying energy, generators also provide the operator with adjustment and operations services to ensure the security, quality and reliability of supply. These adjustment services can also be exchanged with virtual power plants, which can both consume from or supply to traditional generators.

VIRTUAL POWER PLANTS (VPP)

Unlike traditional plants (or traditional generators), virtual power plants are made up of small generators connected to the distribution network, but that are geographically distributed, as is the case for wind generators, cogeneration power plants, photovoltaic systems, small mini-hydro plants and biogas units. The primary objective of VPPs is to provide the grid with both energy and operating services with the same security, quality and reliability conditions as would a conventional power plant. Virtual power plants are thus capable of compensating for fluctuation in demand, hence optimising energy resources in real time.

There are currently examples of VPPs whose implementation has demonstrated the convenience of such installations. For example, the German company RWE Deutschland AG, which operates the distribution network in Germany's northeast, and is the country's second energy producer, installed a VPP that integrates multiple renewable resources and has a current capacity of 80 MW. Through this virtual power plant, RWE supplies energy to the grid via its participation in bulk power within the German electricity market under the framework of the European Energy Exchange (EEX) platform in Leipzig, while also providing the system with secondary and tertiary regulation services (minutes reserve).

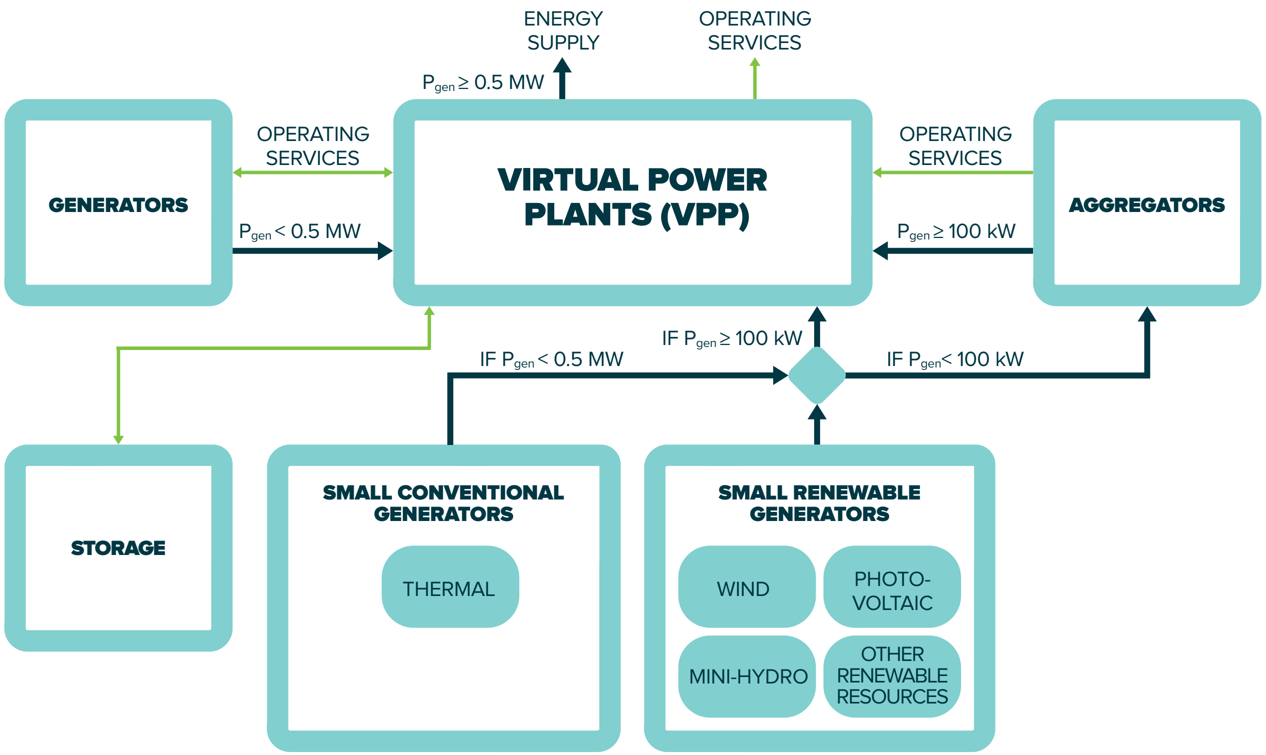


Figure 31. Virtual power plant activity.

Due to the integration of smaller generation resources that can be easily connected and disconnected, VPPs have added operating value, as they are more flexible than large energy generators and can provide flexibility to the electric power system with adequate mechanisms for operation and control.

VPPs can also integrate demand resources to adjust their services to the system's needs, whether directly for larger consumers or through aggregators. Additionally, VPPs can exchange operating services with traditional generators, receiving or offering support from or to the operation of other plants so these may adequately comply with necessities.

In the area under study, VPPs must provide power of at least 0.5 MW as a whole, as has been defined for traditional generators. Generation resources that can be aggregated include:

- Conventional generators with a production capacity of between 100 kW and 0.5 MW, connected to the distribution network.

- Renewable generators with a production capacity of between 100 kW and 0.5 MW, connected to the distribution network.

Smaller generators, with a production capacity of between 10 and 100 kW must make their capacity available through aggregators, as will be explained in the following section.

With regard to ensuring coordination between distributed generation units and provisions for the required adjustment capacity, all generators connected to the distribution network can be integrated within a virtual power plant structure. There must therefore be at least one VPP in each of the areas for which substantial implementation of distributed generation is forecasted.

AGGREGATORS

Like virtual power plants, aggregators are agents that act as intermediaries between small consumers and generators and the electric power system, so these can offer their full potential.

With regard to aggregators as demand resource managers, these agents build flexible substantial demand bundles that can be offered to grid managers and other interested stakeholders. This potential for flexibility can be provided by consumers through the management of flexible demand or through storage systems or the charging of electric vehicles available at the installations. In any case, demand response services must always be of a demand modulation nature (increase or decrease in consumption), but never involve the injection of energy into the grid. Aggregators would be able to offer demand management services to both grid operators (transmission and distribution) for the grid's operating services, or to energy retailers that intend to use these resources to optimise their portfolio of purchased energy for adjustment to the demand of those consumers to whom they supply electricity in a retail market, thus avoiding possible deviation penalties.

Aggregators can also group smaller generation resources so as to create bundles large enough (at least 100 kW) to be admissible by a virtual power plant for use in energy production and to supply the grid. The principal difference between VPPs and aggregators is that, while the mission of the former is to supply the system with power, the latter cannot do so directly, but instead only through the indirect sale of this aggregated generation to a VPP, as seen in figure 32.

Noteworthy in this figure is the aggregator of electric vehicles, which will gradually become more prevalent as electric vehicle penetration increases.

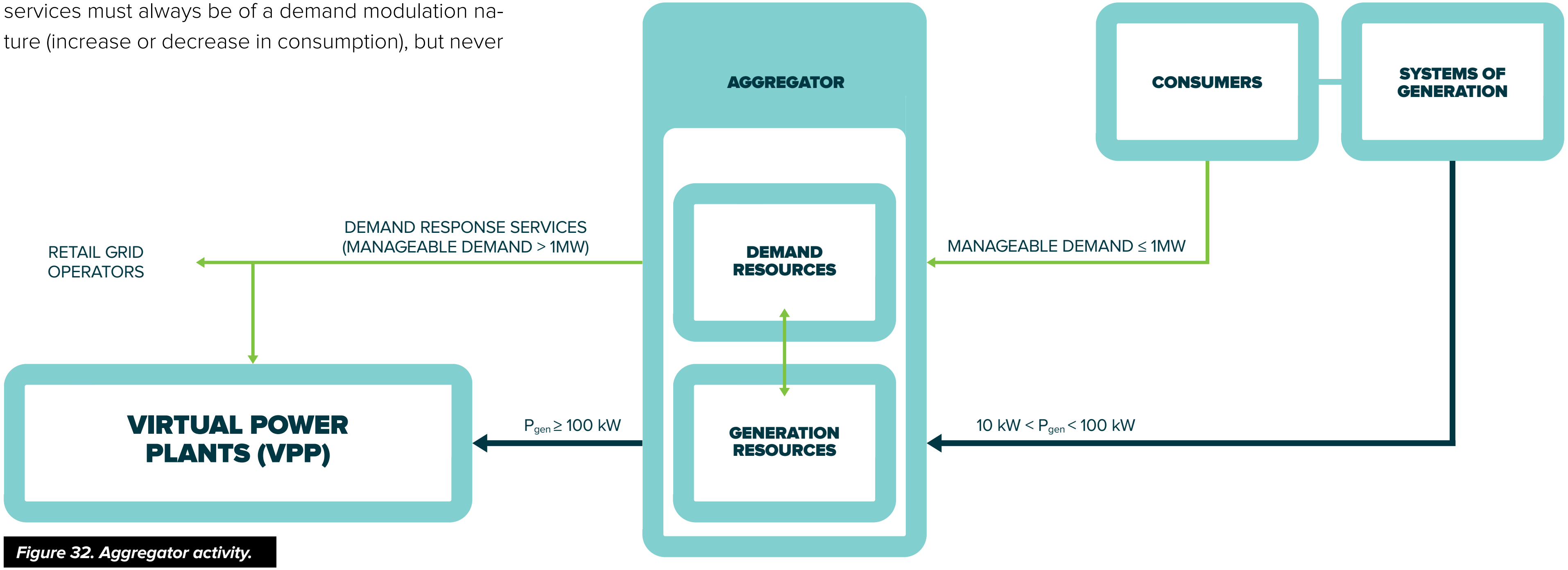


Figure 32. Aggregator activity.

TRANSMISSION SYSTEM OPERATOR

The operator of the transmission system, or simply, system operator, is an entity that carries out the necessary activities to ensure the security and reliability of supply to the whole of the national electric power system, as well as the proper coordination between the production system and transmission network, ensuring that the energy produced by generators is transmitted to distribution networks with those quality conditions that are foreseen in applicable and current legislation. In Menorca, this is done by Red Eléctrica's control centre in Mallorca, as the Spanish power transmission system operator.

Likewise, the system operator is also responsible for mobilising new complementary resource services that may arise through the application of the smart grid concept, and will hence look to VPPs and aggregators to execute the system's frequency and voltage control, reducing costs and benefitting active and smart demand management.

Also forecasted is the implementation of three microgrids associated with Menorca's three principal substations (Ciutadella, Es Mercadal and Maó) and their corresponding distribution systems. The exchange of energy, power and complementary services in the grid shall be provided by transactions made through the transmission grid's physical medium managed by Red Eléctrica de España (REE). The creation of three interconnected smart grids is thus foreseen for support and transfer of energy between them, in accordance with the plan seen in figure 33, all of which will be managed by the transmission system operator.

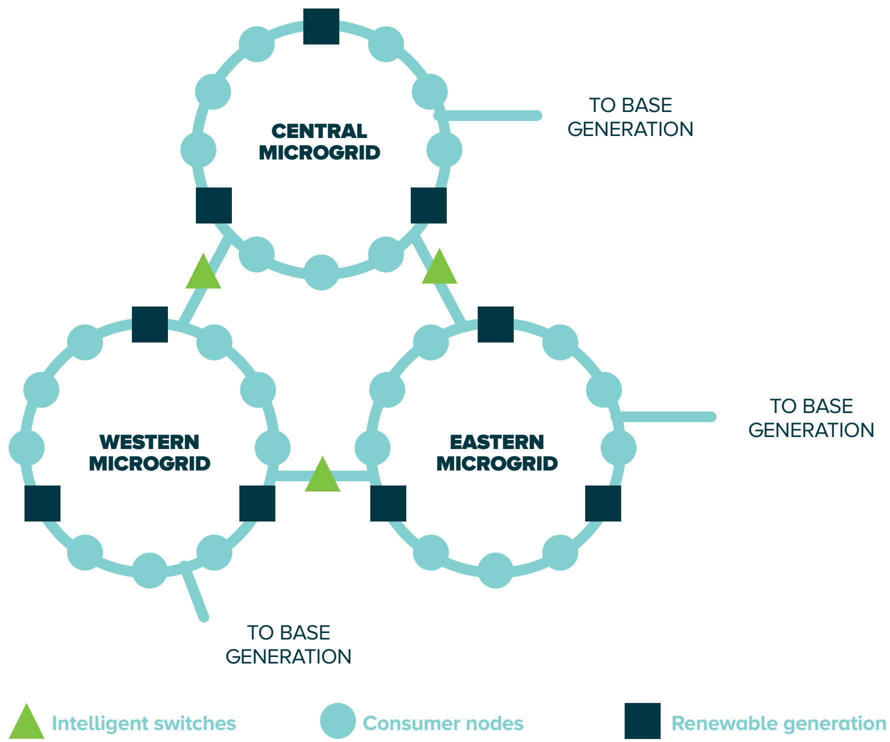
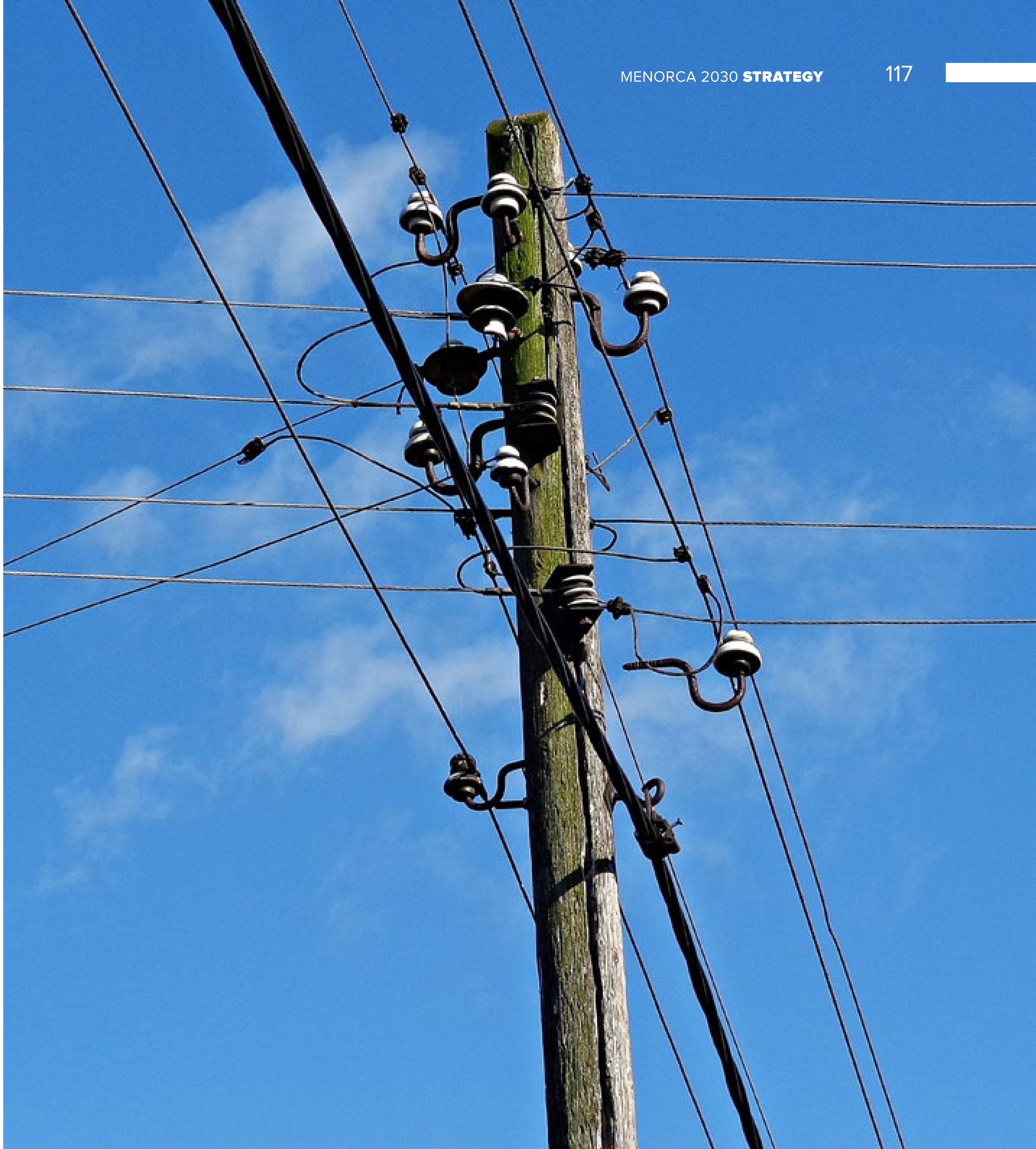


Figure 33. Smart grids in Menorca's distribution system connected by a 132-kV grid.

The application of this innovation within the transmission network, based on power electronics and through the development of smart and constructive solutions for electrical engineering services, becomes an excellent support tool for system operation and materialises as high-voltage elements that automatically regulate and control power flow and voltage. They also deliberately modify the parameters that affect electricity demand, maintaining a more adequate balance for the transmission network, while also reducing costs of the electric power system by maximising the integration of renewables. Examples of this technology include the installation in the transmission network of equipment like redirectors of flow, phase shifters, STATCOM, flywheels and storage systems. Some of these form part of Spain's Electrical Planning, while others, due to their more limited technological maturity, exist as research and technological development (RTD) projects.

DISTRIBUTION OPERATOR

Like the system operator, distribution operators manage the distribution network of the area under their domain to exclusively ensure electric power supply to final consumers connected to this grid, while guaranteeing conditions of secure and quality supply as established by current legislation. However, operators of the distribution network neither buy nor sell electricity, as such actions are carried out by other stakeholders (retailer energy providers) who make use of the distribution network. Their services, like those of the grid owners, would be compensated by all consumers connected to the distribution network of their domain through fees or charges based on voltage levels, consumption and installed power. In the case of Menorca, distribution networks are managed exclusively by Endesa Distribución, as the owner of the island's entire distribution network, which would receive support from new stakeholders (VPPs and aggregators) to ensure electric power supply while maximising and incentivising the integration of new renewable resources for electricity generation.



2.5.5. Communications infrastructure

With the evolution of conventional distribution networks toward smart grids, it will become necessary to improve the communications between control centres and their respective distribution substations. It is hence proposed to implement a design for communications that integrates the new elements of smart grids into distribution networks and allows for automated distribution, smart and bidirectional metering and the management of distributed energy resources.

The communications design must include three fundamental aspects for the implementation of smart grids in Menorca from a communications perspective:

- Distribution automation (DA)
- Advanced metering infrastructure (AMI)
- Management of Distributed Energy Resources (DER)

Bearing in mind that distribution networks will evolve into smart grids, which implies the introduction of smart meters as part of the system, the integration of distributed energy resources, and field devices (connectors, sectionalisers, disconnectors, fault indicators, capacitor banks, etc.), it will be necessary to take steps toward improving communications for the 20 control centres and their respective distribution substations, taking full advantage wherever possible of fibre optics or other high-performance technologies.

Connected to the substation's grid will be data concentrators, intelligent electronic devices (IED) and substation meters, which should be directly connected to the grid via Fast Ethernet, with devices that use master-slave type serial communications becoming less common.

From among the recommended communications standards for the automation of distribution under a system of smart grids, noteworthy is the IEC 61850 communications standard, which is proposed as the sole standard within the substation grid, and between this and the control centre. This protocol is continuously evolving to integrate new elements from smart grids into distribution networks, as is the case of distributed energy resources.

One key element from within smart grids is the smart meter, as a cross-border element with consumers, as the principal players from smart grids. One of the main differences between the meters from an AMR (automatic meter reading) system and smart meters is the change in the communications framework, moving from unidirectional communication, where only the data stored in the meter is gathered, to bidirectional communication, in which it is the very meter that can initiate communication, hence opening a wide array of new functions, like for example, alerts for the absence of voltage at the meter's input before switching off.

These devices allow for remote readings, also available with their predecessors, although now incorporating significant new functions for management by a distributor, like remote disconnection and connection of consumers due to non-payment, resulting in considerably reduced costs and time required for such processes.

These devices can be remotely configured and updated, and can limit the power demanded by a consumer and incorporate adequate programming, such that in case of failure due to excess power, the user can re-establish the connection through the protection panel without having physical access to the meter.

These units can be utilised as communication gateways, serving as liaisons between the customer's home area network (HAN) and the meter's communications network. This option has not been deemed optimal for the implementation of demand response due to the delays caused by this type of implementation.

From a communications design point of view, the AMI system is divided into different parts based on proximity to the endpoints. As shown in figure 34, a distinction can be made between backhaul (WAN distribution network) and access communication (NAN/FAN network).

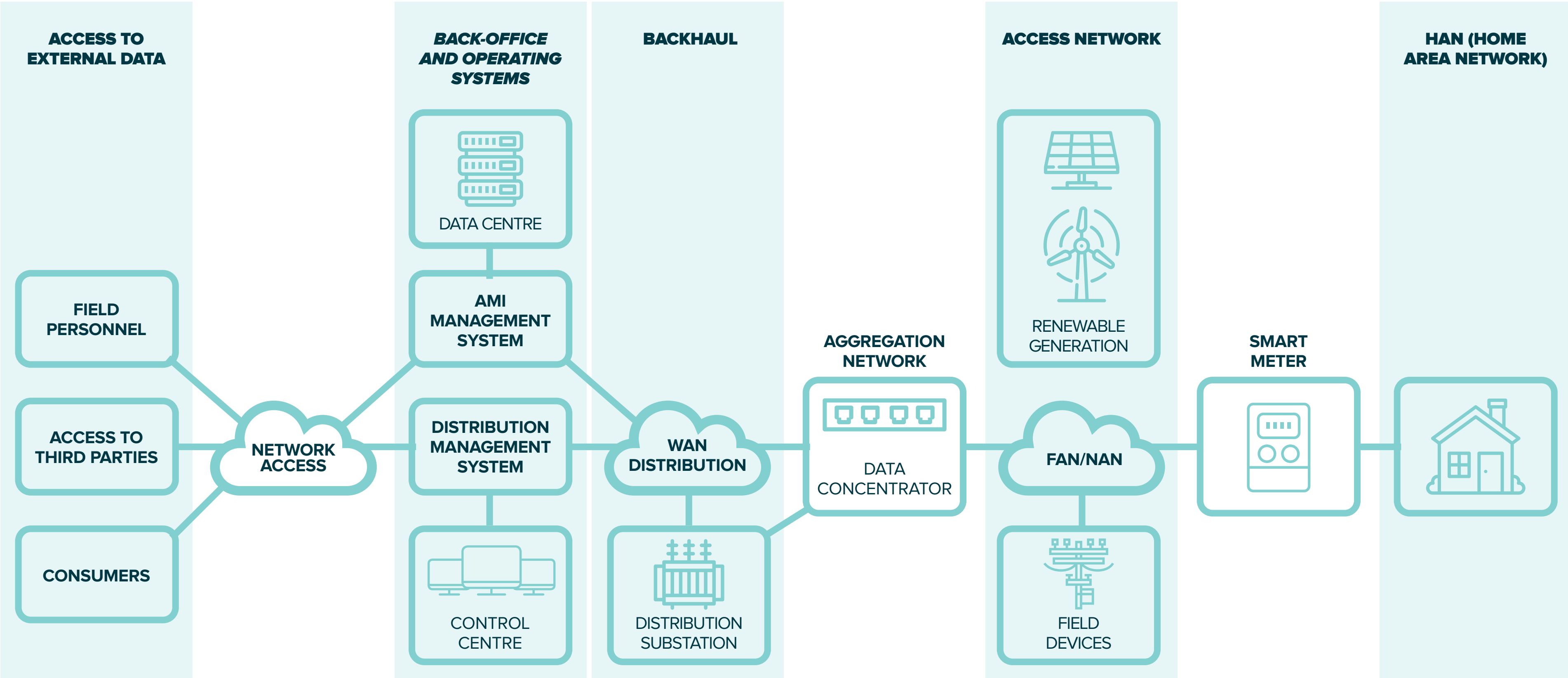
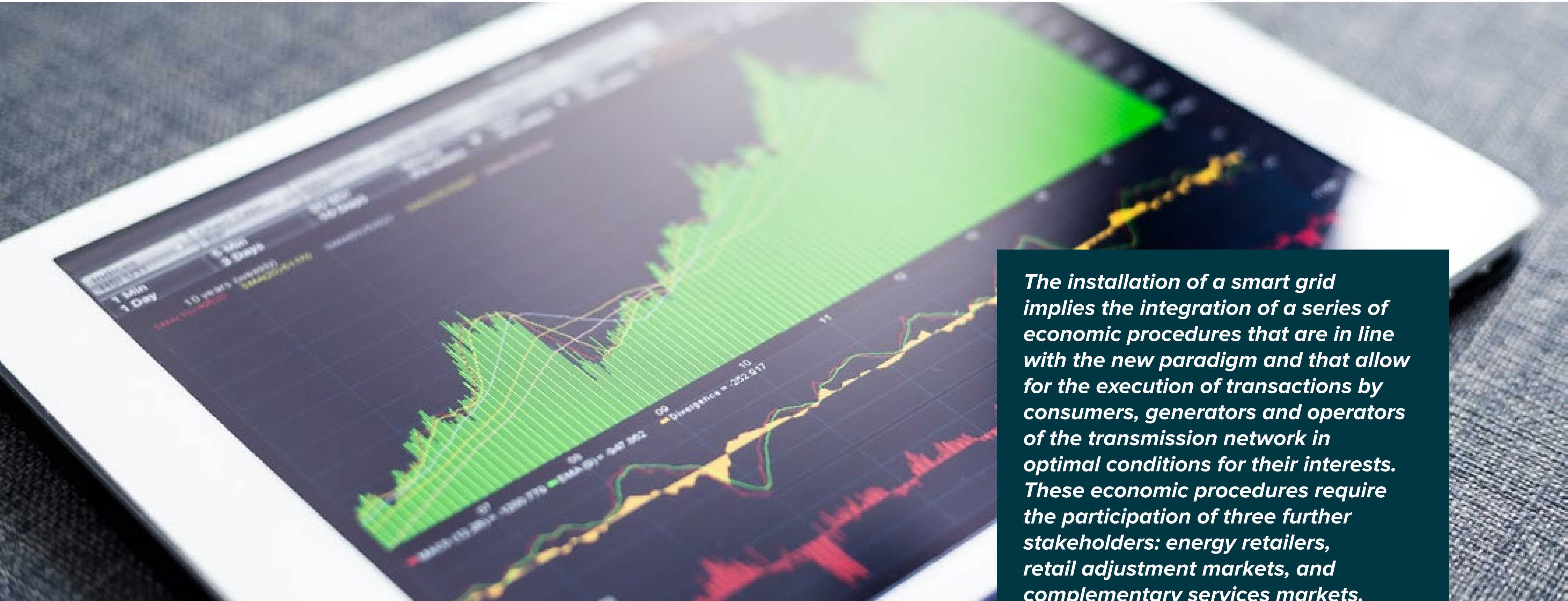


Figure 34. AMI communications design.

One of the most significant aspects when designing the communications infrastructure of an AMI system involves the access network, as the part of the network that joins the backbone to the end devices. This network is divided into two different parts: the aggregation network and what is known as the "last mile" network. At present, there are two differing tendencies when adopting a valid solution for the design of this part of the network. On one hand, American networks primarily make use of technologies of radiofrequency; and on the other, European countries, which due to restrictions regarding wave emissions, more commonly use PLC (programmable logic controller) technology.

Each of these solutions has its inherent advantages and disadvantages, but fortunately there are currently retail solutions that combine the two and utilise devices with dual band communications with RF Mesh and Power Line Communication (PLC). This technology is more flexible and selects at any given moment the optimal means of communication available and dynamically determines the fastest and most reliable route according to the network's operating conditions.

2.6. MECHANISMS FOR SMART MARKETS



The installation of a smart grid implies the integration of a series of economic procedures that are in line with the new paradigm and that allow for the execution of transactions by consumers, generators and operators of the transmission network in optimal conditions for their interests. These economic procedures require the participation of three further stakeholders: energy retailers, retail adjustment markets, and complementary services markets.

The introduction of a smart grid, as has been described in previous sections, must be complemented by a series of economic procedures that allow for:

1. The execution of transactions such that energy consumers can be provided with the energy they require in optimal conditions of price and quality.

2. The execution of transactions such that generators (both traditional and virtual) can sell the energy they produce in the most advantageous way possible based on the applied generation technologies.

3. The execution of economic transactions on the part of the operators of the transmission and distribution networks that provide them with the necessary resources to operate their networks in a reliable, secure and economically optimised manner. These resources can be supplied by generators, both traditional and virtual, consumers or aggregators, as described in the previous section.

The fulfilment of transactions and contracts in the local market that creates a smart grid must result in the consumers' ability to negotiate their demand and generation resources in a simple and secure manner, guaranteeing competitive pricing that adheres to the resource's fair market value.

In Menorca's case, and in accordance with established objectives for renewable generation, short and medium-term transactions will be prioritised, which will add an increased level of difficulty to transaction mechanisms, as it is challenging to produce long-term previsions for generation. In hopes of optimising the system's economic operation, consumers and aggregators must be provided with applications that predict demand, while generators must have, in turn, similar tools that foresee renewable generation in the most reliable manner possible.

The implementation of these transactions requires the participation of three additional stakeholders beyond those defined above: energy retailers, spot transaction markets and complementary services markets.

2.6.1. Energy retailers

These can utilise the demand resources provided by their own consumers or by aggregators to better adjust their consumption to the energy previously acquired in the wholesale market in real time. To do so, they must have their customers' detailed consumption and generation measurements available to them. Their profits are based on the markup applied to the prices they pay for energy in the wholesale market.

Energy retailers are those companies that, via the distribution operators' networks, sell electricity to the final consumer, and are the primary point of contact for consumers when contracting electricity service. To do so, energy retailers obtain their supply by purchasing large energy bundles either on the wholesale market or through bilateral contracts with generators (traditional or virtual), to subsequently supply this energy to final consumers through retail market mechanisms, thus acting as a liaison between the two markets.

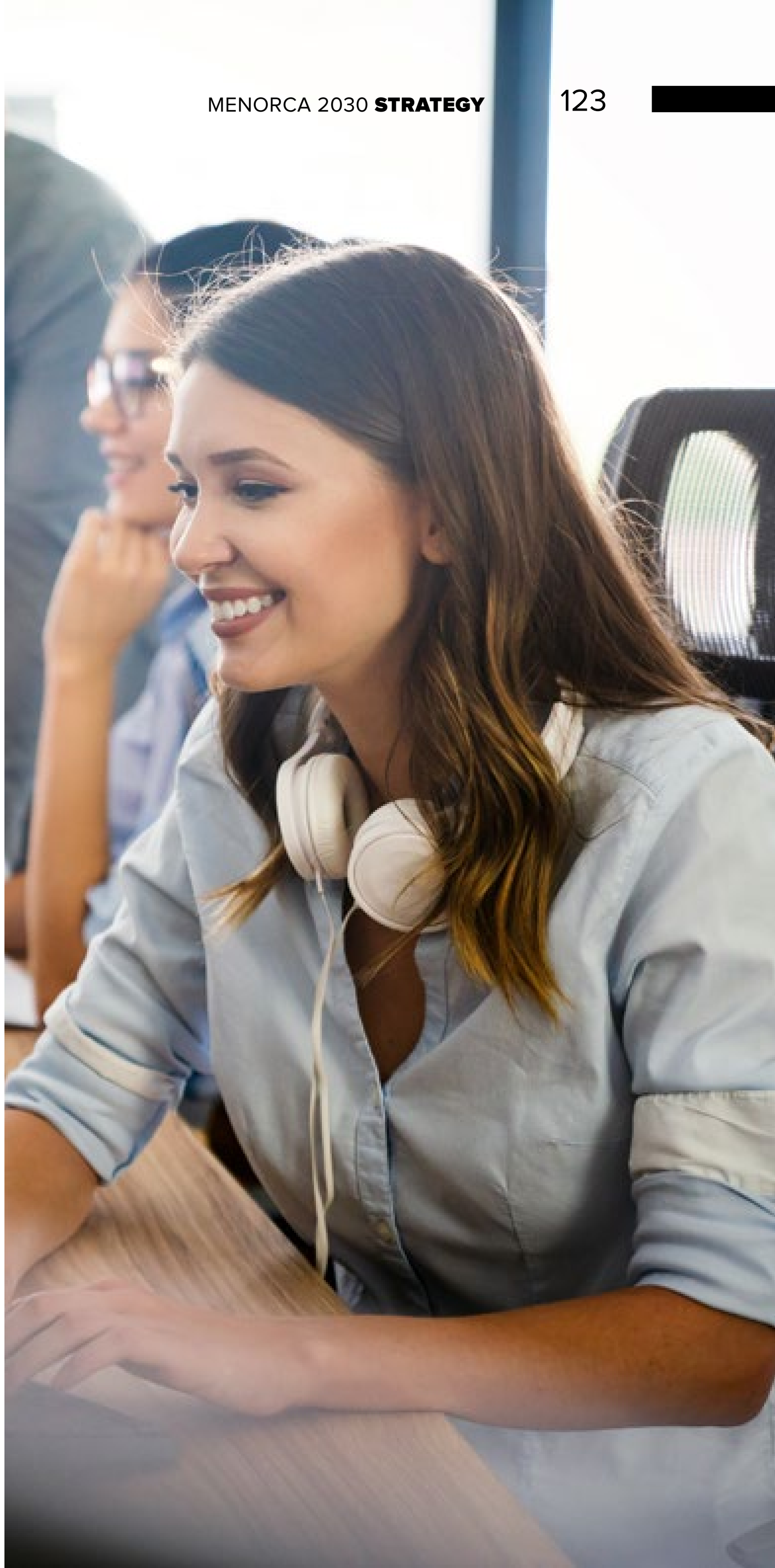
To make purchases on the wholesale market, energy retailers must execute demand forecasts for the consumers to whom they supply energy. The differences that always exist between purchased energy and supplied energy result in deviations for which the energy retailers must pay the wholesale market, normally at a quite elevated price. To better adjust real-time consumption to the previously acquired energy from the wholesale market, the retailer could make use of demand resources provided by their own consumers or aggregators.

Energy retailers must have detailed measurements for consumption, and where applicable, a consumption-generation balance for the customers they supply. The corresponding measurements will be provided by the distributor, as the entity responsible for measurements within the distribution network, and subsequently, for determining the grid's energy influx and outflux.

The profits obtained by energy retailers from their operations stem from a markup applied to the prices they pay for energy in the wholesale market, having covered all expenses related to their operations (grid losses, adjustment services, fees paid for grid access, payments to operators, etc.).

Retailers must have sufficient financial capacity as required by their activity, in that they must obtain a stock of large amounts of energy before it can be supplied to and paid for by their final consumers.

Purchase transactions made by energy retailers can be made independently with potential OTC (over-the-counter) suppliers or through a platform designed to this end (PowerExchange, PX).



2.6.2. Spot transaction manager

The mission of the spot[20] transaction manager is to provide the necessary mechanisms for the purchase and sale of energy in the short term (typically one day) such that the system's various purchase and sales agents can obtain stock or adjust their positions that result from bilateral transactions (medium and long-term) to the supply situation in which generation must be instantaneously adjusted to consumption plus losses.

The proposed spot market can function through various mechanisms. The first could consist of one or multiple sessions (daily, intraday, etc.), managed by the corresponding transaction manager. In this model, production companies freely communicate the conditions for quantity and price at which they would be willing to sell electricity from their installations on a daily basis, with the grid operator responsible for initially establishing how much energy to produce with each power generation unit contingent on market results, taking into account both production supply as well as energy purchases. At a later stage, following market results, the operator of the electric power system would determine the definitive quantities to produce, once the market results are adapted to the grid's physical conditions.

Another way to organise this adjustment market could be through short-term bilateral contracts that would be freely negotiated between purchasing and sales agents, or through an exchange platform (typically known as a PX), in which the regulator would require the publication of indexes related to the types of products and average prices to be negotiated. In this latter case, it would also be necessary to create extremely short-term mechanisms (just hours before dispatching) so as to achieve resources that balance generation and demand.

The energy transactions required for smart grid operation will be based on bilateral transactions that will be freely negotiated and retail transactions executed through a PX electronic platform.

2.6.3. Complementary services manager

The complementary services manager provides mechanisms for the purchase and sale of energy and adds active and reactive power reserve products in the short and medium term.

This manager could be identified with the spot transaction manager, including, in addition to energy products, short and medium-term active and reactive power reserve products.

The entire operation would be carried out through those stakeholders defined in section 2.5 above, coordinated in accordance with the dynamic transactions that have been detailed in the markets described in this section.

[20] The spot market or cash market is one in which commodities are traded for immediate delivery at the market price at the very moment of transaction. This market contrasts with the futures market, where delivery of the commodity is made at a later date.

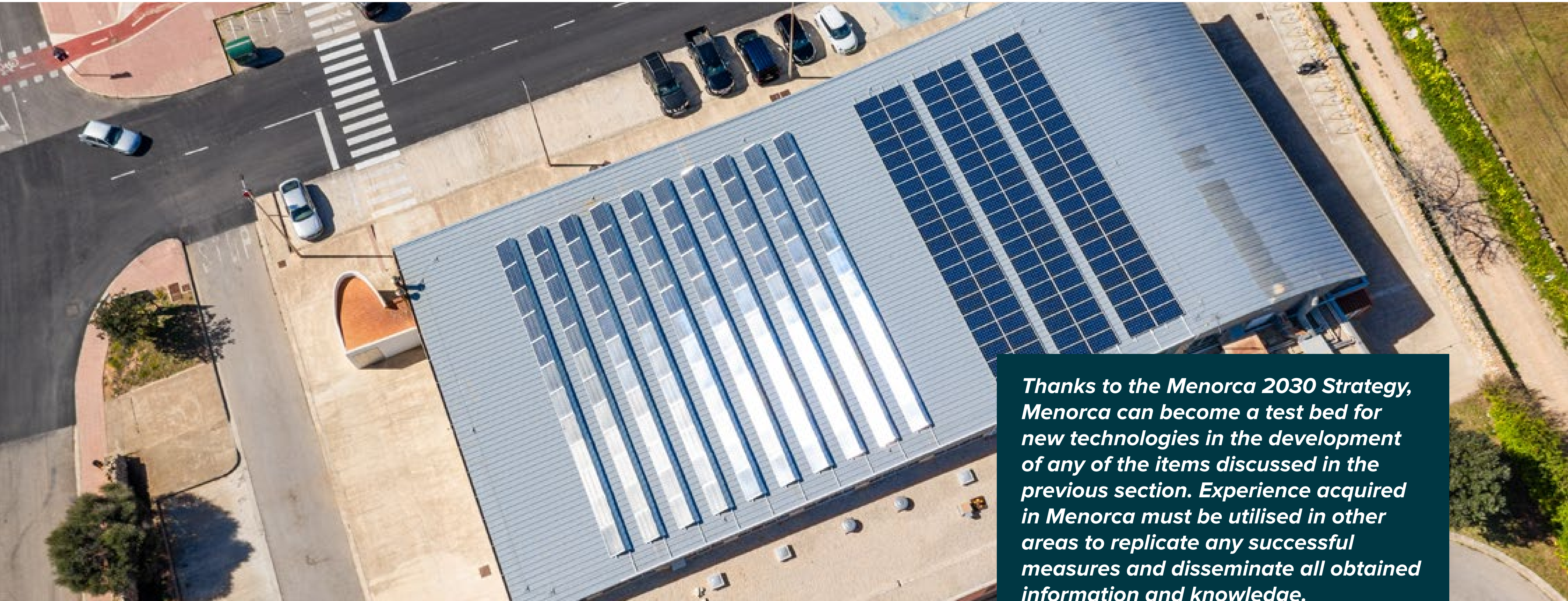
2.7. THE MENORCAN ENERGY COMMUNITY

Of vital importance is the involvement of Menorcan society in this energy transition as an active participant in decision-making and to bolster change in the energy model by adapting the community's habits to more efficient consumption, which in turn has a direct effect on the local economy.

ACTIONS

- Enlist public participation on the part of the Menorca 2030 Energy Office (see section 6) and the Menorca Biosphere Reserve Agency to involve society in the energy transition process.
- Create a centre for excellence and good practices for the design and introduction of renewable energies, so as to attract talent, expertise and industry to the concept of sustainability.
- Introduce energy transition into official educational programmes and areas of higher education.
- Create and promote formulas for collective participation in the financing of new energy assets.
- Foster the creation of businesses, professionals, co-ops and associations that set objectives, provide expertise and offer services associated with energy and the transition process toward decarbonisation.
- Promote transparency in those actions that are carried out so the general public can take on a more proactive role in the monitoring of results.
- Create a public advisory service intended to develop systems for the monitoring, control and optimisation of consumption, use of installations and improvements to be implemented on a household level.
- Train personnel from the primary and industrial sectors in matters of efficacy and efficiency for production processes.
- Implement an information and training programme for energy stakeholders from the public sector.
- Carry out demonstrative measures with community involvement in high-consumption buildings of the public administration

2.8. NOTEWORTHY PROJECTS



Thanks to the Menorca 2030 Strategy, Menorca can become a test bed for new technologies in the development of any of the items discussed in the previous section. Experience acquired in Menorca must be utilised in other areas to replicate any successful measures and disseminate all obtained information and knowledge.

Examples of projects that are replicable in or transposable to other territories include:

- ☑ **Design of methodology and implementation of the associated instruments for the planning, monitoring and control of rapid energy transition on geographical islands.**

  Establish monitoring and control systems for any and all implemented measures and any effects these produce through application of KPIs (Key Performance Indicators) and sensitivity analysis for the key factors of the process.

- ☑ **Pilot projects for electricity storage installations in Menorca: optimal sizing, management and operation.**

  Analysis and sizing of the system optimised for Menorca's specific case, such that it can be replicable in other territories.

- ☑ **Conversion of a business park to a status of energy self-sufficiency.**

  In the currently existing business parks found around Menorca, there are sites that could be capable of such transformation, especially considering the already established commitment from business associations to launch this project.

- ☑ **Demonstrative project for the restoration of residential buildings to achieve their status as nearly Zero-Energy Buildings (nZEB).**

  These efforts involve attempting such restorations in social housing buildings, as well as in given privately owned residential buildings so as to monitor pre and post restoration status and replicate experiences.

- ☑ **Demonstrative project for the construction of a new residential building with status as a nearly Zero-Energy Building (nZEB).**

  The execution of this project will be prioritised for social housing buildings.

- ☑ **Project for the sustainable comprehensive resource management for the Menorca Airport.**

  As the largest consumer of energy in all of Menorca, a comprehensive project is proposed that includes the installation of renewable generation, increased demand flexibility, electrification of transportation and a rainwater catchment system.

- ☑ **Large-scale introduction of improvements made to buildings' envelopes via the EuroPACE system.**

  This financing scheme will facilitate notable improvements to a majority of the existing buildings' envelopes, resulting in greater energy efficiency.

- ☑ **Creation of a technical and training centre for energy efficiency and renewable energies.**

  This centre will serve to train designers, technicians and business owners.

- ☑ **The Milà biogas plant.**

  This plant is already in its preliminary design phase, and will make use of the gases produced at an urban landfill to generate electrical energy.

This list is of course not final, and with the evolution of technology, knowledge and experience, it will expand into other examples.

3 Top 10 Menorca 2030 strategic interventions

A series of measures foreseen within the Menorca 2030 Strategy stand out for their notable impact on the achievement of the established objectives for energy transition.

The Menorca 2030 Strategy responds to a comprehensive approach on the energy transition process that must occur on the island to comply with the established objectives, and thus includes all actions necessary for execution in all key areas.

That said, there is a series of foreseen measures that stands out over the rest for their more notable impact toward the achievement of goals, and which have been laid out in the previous section.

1

Development of renewable energies in the Milà waste management area.
An existing project envisages the installation of a renewable generation zone in the Milà area through the hybridisation of wind, photovoltaic and biogas energy with a total expected power level between 18 and 20 MW.

2

Son Salomó photovoltaic plant.
This solar park is already authorised and will have a total installed power of 49.8 MW. Although this type of installation is relatively large in comparison with the model intended for implementation around Menorca, it will have a large impact on increased generation levels from photovoltaic solar energy.

3

Storage batteries.
Such equipment is intended for the large-scale accumulation of energy produced in Menorca with renewable energies at moments of surplus production, for use when production is insufficient, hence minimising the importation of energy from off the island.

4

Self-supply in buildings.
This will bring energy generation and consumption together, while also helping to achieve community involvement in the penetration of renewable energies.

5

Photovoltaic plants in public urban parking areas.
This will allow for the exploitation of areas used as car parks, with no other specific use, to be used in the generation of electrical energy with photovoltaic plants, without jeopardising additional areas.

6

EuroPACE Menorca Programme.
Thanks to the EuroPACE Programme, owners of businesses, dwellings and buildings will have available financing to carry out refurbishments and renovations aimed at improving their buildings' envelopes and thus improve energy efficiency.

7

Electric transport and charging infrastructure.
The electrification of transportation is of vital importance, and to do so the availability of an adequate charging infrastructure is essential.

8

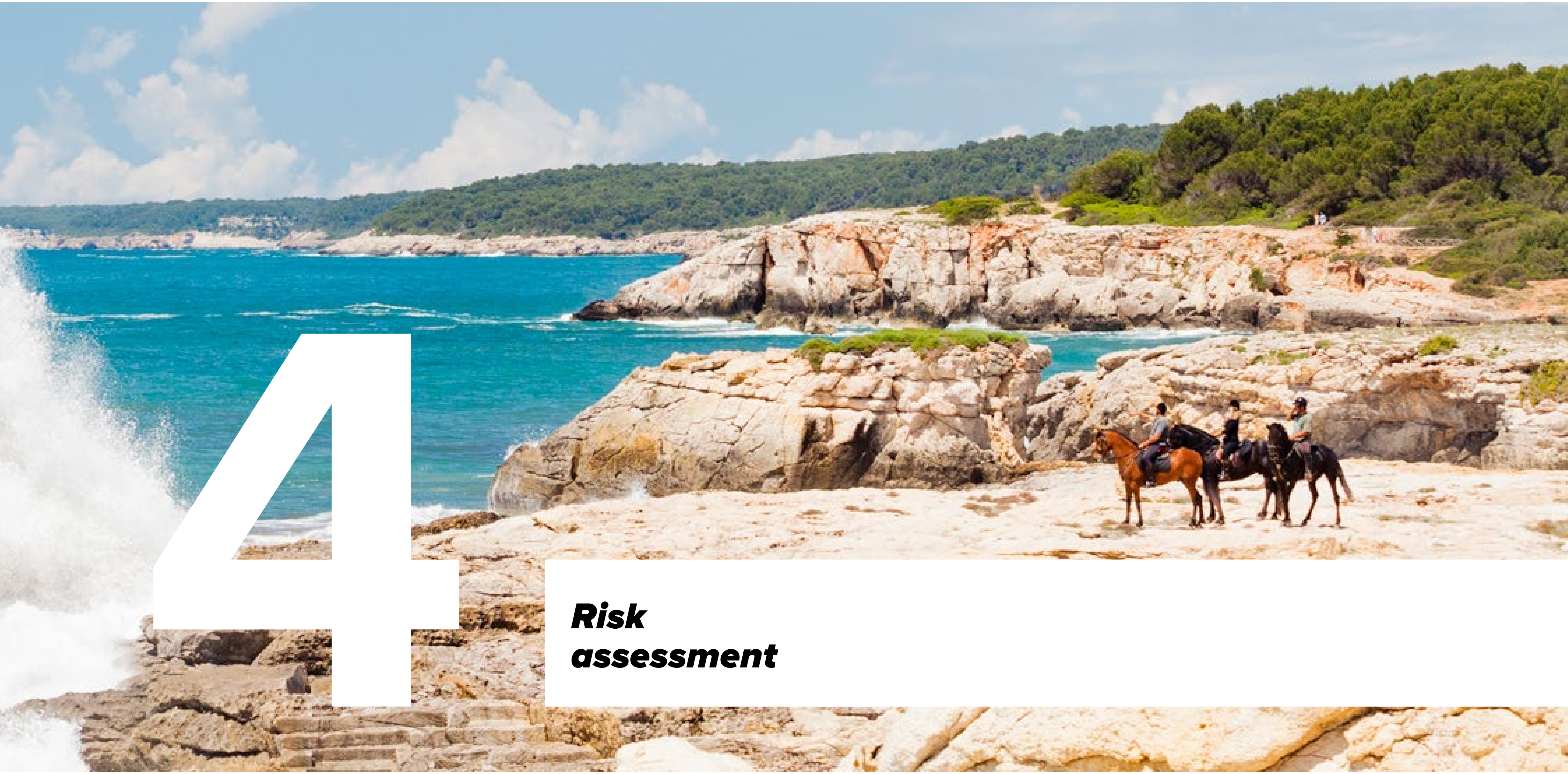
Implementation of smart grids.
To allow for the penetration of renewable energies, it is crucial that the electrical power system is managed virtually automatically, hence turning the current grids into smart grids.

9

Local energy markets.
Another aim is to use Menorca as a "sandbox" to analyse technological or regulatory innovations that may be necessary to achieve energy transition goals.

10

Menorca 2030 Energy Office.
This office will serve an advisory role for the community with regard to issues involving renewable energies and energy efficiency, including assistance with administrative procedures, possible subsidies and technical consultation.



4

Risk assessment

Certain obstacles have been identified that could arise in the process of execution of the measures planned under the Menorca 2030 Strategy.

- A lack of a well-defined and stable long-term compensatory system.
- Complex and excessively prolonged administrative procedures.
- Electrical distribution infrastructures with structural issues caused by a deficiency in network meshing.
- Electrical interconnection required with Mallorca for grid stability and adequate energy flow management when faced with over or underproduction.
- The rate of renewable penetration must be accompanied by an equivalent increase in the electric power system's management and regulation capacity, thus requiring a certain amount of storage capacity.
- Obsolete regulations for grid access and connection. A lack of available information regarding the state of the grid to forecast connection points of new plants in the planning stage, especially with regard to evacuation capacity at each point on the grid.
- Regulation of the compensation system for energy generation does not take into account the insular situation. The definition of a special compensatory framework may be necessary.
- Territorial and urban planning must be adapted to facilitate the penetration of these types of installations.
- The need for detailed evaluation of wind resources at each site.
- The need for training of specialised professionals who can carry out operations and maintenance on wind installations.
- The various city halls must coordinate their ordinances to facilitate installations in urban areas and provide tax benefits. With regard to biomass, permitted sites must be defined for collection.
- A business structure must be created for the extraction, collection and distribution of biomass for thermal uses.
- Adaptation and/or renovation may be required for the systems of existing buildings.
- Generation technologies in marine environments are not exploited in the Balearic archipelago, making it necessary to adapt planning measures and authorisations to facilitate their introduction.
- The lack of a legal framework for storage.
- To improve the management of all resources, both photovoltaic and electric vehicles, smart systems must be installed for the joint management of production, vehicles and battery storage systems that include communication and visibility on the part of both the distribution network operator and the system operator.

5 *Regulatory, planning and legislative measures*

Based on the risk assessment and actions laid out in previous sections, the need to adopt and prioritise certain regulatory measures that facilitate the execution of the necessary actions grows apparent. In this section, the different levels of responsibility and jurisdiction for the adoption or promotion of any necessary measures are explained.

NECESSARY MEASURE/UNMET NEEDS	RESPONSIBLE OR COMPETENT ADMINISTRATION			
	CITY HALLS	ISLAND COUNCIL OF MENORCA	AUTONOMOUS COMMUNITY	STATE ADMINISTRATION
Territorial and urban planning must be adapted to facilitate the penetration of these types of installations.	✓	✓	✓	
The various city halls must coordinate their ordinances to facilitate installations in urban areas and provide tax benefits. With regard to biomass, permitted sites must be defined for collection.	✓			
Generation technologies in marine environments are not exploited in the Balearic archipelago, making it necessary to adapt planning measures and authorisations to facilitate their introduction.			✓	✓
Measures for reduced traffic in urban environments.	✓			
Urban planning that incorporates actions aimed at transportation and emissions reductions.	✓	✓		
A lack of a well-defined and stable long-term compensatory system.				✓
Develop mechanisms for seasonal compensation of self-supply installations with grid feed-in.				✓
Measures to incentivise low-emissions vehicles and/or more efficient systems with measures like, for example, the delimitation of areas of transit that do not allow high-emissions vehicles, or special parking for shared or low-emissions vehicles.	✓	✓		
Regulation of the compensation system for energy generation does not take into account the insular situation.				✓
For energy storage, the definition of a special compensatory framework may be necessary.				✓
A lack of a legal framework for energy storage.				✓
Complex and excessively prolonged administrative procedures.	✓	✓	✓	✓
Planning for electrical interconnection between systems.			✓	✓
Obsolete regulations for grid access and connection.			✓	✓
A lack of transparency regarding the state of the grid and its management.				✓
Detailed evaluation of wind resources for each site.			✓	✓
The need for training of specialised professionals for operations and maintenance on wind installations.			✓	✓
A business structure must be created for the extraction, collection and distribution of biomass for thermal uses.		✓		
Adaptation and/or renovation may be required for systems of existing buildings.	✓	✓		
To improve the management of all resources, both photovoltaic and electric vehicles, smart systems must be installed for the joint management of production, vehicles and battery storage systems that include communication and visibility on the part of both the distribution network operator and the system operator.			✓	✓
Modernisation and improvement of the distribution network meshing.			✓	✓
Adaptation of guidelines of various regulations and laws related to local tax authorities and municipal authorities for the introduction of EuroPACE.				✓
Create a specific brand for tourism-based businesses that are committed to objectives of decarbonisation.		✓	✓	

6 *Stimulus office*

The Menorca 2030 Energy Office is meant to serve as a facilitating agent that is made up of the principal stakeholders, promoting community participation and training. The office would have the authority to provide financing and execute pilot projects, becoming a component of the network of territories and centres that prioritise a change in energy model.

As a facilitating agent, the Menorca 2030 Energy Office shall take on the following roles:

- Dialogue and reference point for all energy-related issues in Menorca.
- Training, both on a basic educational level and for professional preparation.
- Funding:
  - Authority to finance initiatives consistent with Menorca 2030 objectives.
  - Presentation of applications for financing projects.
  - Accumulation of capital for project financing.
- Monitoring and tracking of this roadmap for Menorca.
- Facilitate community participation.
- Technical and legal consulting for public and private sectors.
- Communication, training and empowerment of the community in matters of energy.
- Promote pilot schemes of a demonstrative nature.
- Actions of dissemination and awareness.
- Proposals for the modification of regulations.

7 *Objectives roadmap*

2020

- Electrical connection with Mallorca (operating capacity 35 MW)
- 18% of electricity demand covered by renewables: 53.1 MWp PV; 3.2 MW wind; 3.2 MW self-supply in urban settings
- Launch of the Menorca 2030 Energy Office
- Launch of the EuroPACE Programme

2025

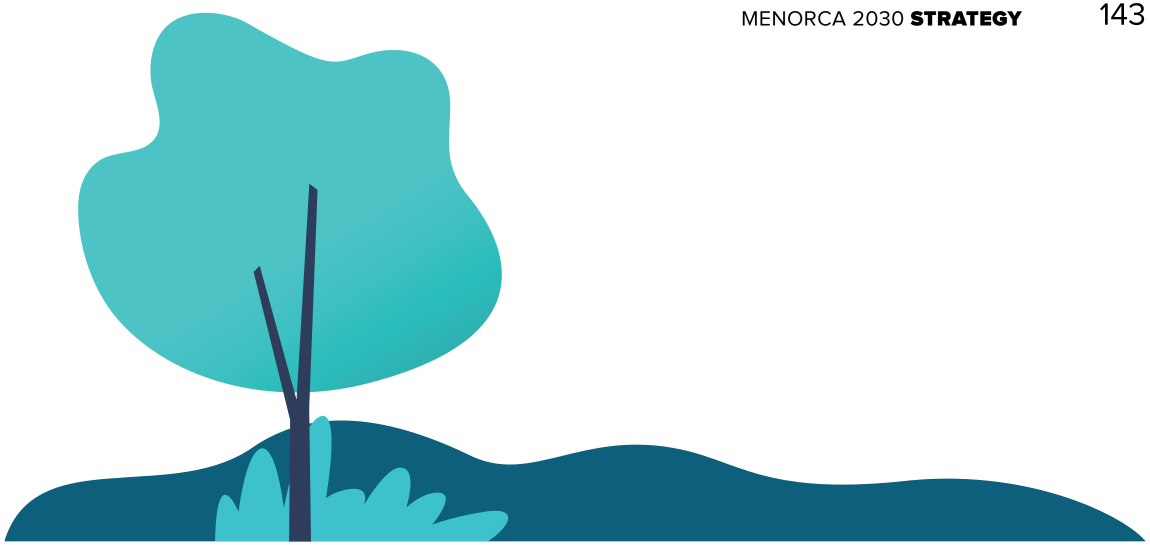
- Dual electrical power link with Mallorca (operating capacity 90 MW)
- 54% of electricity demand covered by renewables: 160 MWp PV; 10 MW wind; 15.2 MW renewables in urban settings
- Natural gas as the fuel source for the thermal power plant
- 15% reduction in fossil fuel consumption in land transport
- 15% reduction in fossil fuel consumption for thermal uses in the service, residential and industrial sectors
- 2% reduction in red diesel in the primary sector

2030

- 85% of electricity demand covered by renewables: 261 MWp, PV; 16.5 MW wind; 30 MW renewables in urban settings; 4 MW other technologies; 400 MWh storage
- 50% reduction in fossil fuel consumption in land transport
- 30% reduction in fossil fuel consumption for thermal uses in the service, residential and industrial sectors
- 10% reduction in red diesel in the primary sector

8 *Reference indicators*

To correctly monitor objectives, a set of established reference indicators will allow for the adequate tracking of compliance, as well as their evolution within the different sectors.

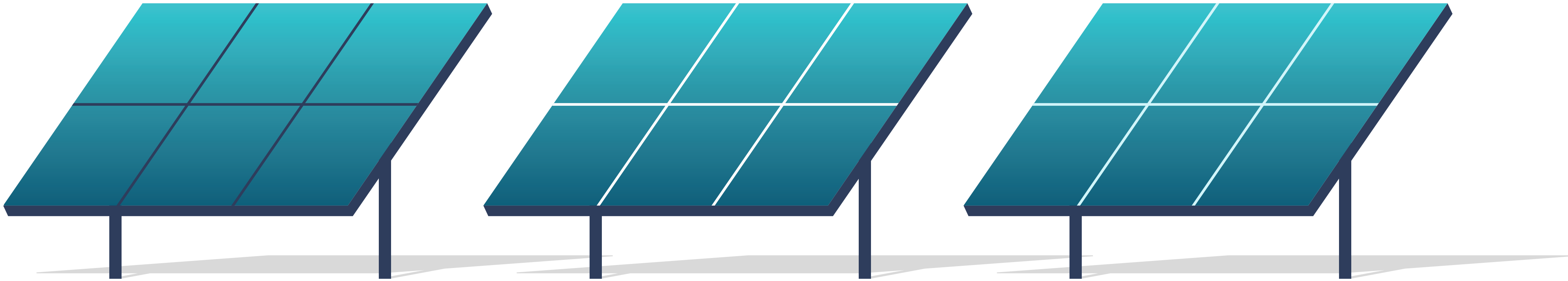


I. ELECTRIC POWER SYSTEM	2013 Value	Units
Annual electricity production and importation	484,059	MWh
Percentage of insular renewable electrical generation	3	%
Emission factor for generated electricity	0.75	tCO_2/MWh
Installed wind power	3.2	MW
Installed photovoltaic solar power	5.1	MWp
Installed power from renewable self-supply	-	kW
Annual billed electricity consumption	440,601	MWh
Annual electricity consumption per capita (actual population)[22]	3,856	kWh/person

II. LAND TRANSPORT	2013 Value	Units
Annual fuel demand for transport[23]	478,599	MWh
Annual fuel demand for transport per capita (actual population)	4,189	kWh/person
Number of electric automobiles[24]	0	Units
Electric vehicles as percentage of total vehicles	0	%
Number of electric motorcycles	17	Units
Electric motorcycles as percentage of total	0	%
Annual average daily traffic from the sensor at km marker 20.4 of the Me-1 main road	9,066	Vehicles/day
Number of passengers on regular public transportation lines	2,060,359	Units

[22] *The term "actual population" includes both residents and visitors prorated on an annual basis.*

[23] *Fuel supplied from petrol stations. Due to a lack of disaggregate data, this value includes recreational boating.*
[24] *Indicators related to motorised vehicles and their corresponding values refer only to vehicles registered in Menorca.*



III. RESIDENTIAL, SERVICE, INDUSTRIAL and PRIMARY	2013 Value	Units
Annual consumption of LPG	59,915	MWh
Annual consumption of heating oil	96,495	MWh
Annual consumption of natural gas	8,251	MWh
Total annual consumption of LPG, heating oil and natural gas	164,661	MWh
Total annual consumption of LPG, heating oil and natural gas per capita (actual population)	1.44	MWh/person
Annual consumption of red diesel	38,556	MWh

IV. OVERALL INDICATORS	2013 Value	Units
Direct CO_2 emissions[25]	542,395	tCO_2
Direct CO_2 emissions per capita (actual population)	4.75	tCO_2/person
Annual consumption of primary energy	2,254,347	MWh
Annual consumption of primary energy per capita (actual population)	19.73	MWh/person
Annual consumption of secondary energy	1,169,724	MWh
Final annual energy consumption	1,126,138	MWh
Final annual energy consumption per capita (actual population)	9.86	MWh/person

[25] *Indicators related to either CO2 emissions or energy consumption do not take air or maritime transport into account in any case.*

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*Register of institutions, entities, associations and businesses that have expressed their explicit support for the Menorca 2030 Strategy**

PUBLIC INSTITUTIONS

- UNESCO –MaB Programme (Man & Biosphere)
- Ministry of Ecological Transition and Demographic Challenge
- Balearic Islands Government Delegation
- Balearic Islands Government Delegation – Insular General State Administration Office in Menorca
- Balearic Islands Government – Ministry of Territory, Energy and Transport – Directorate-General of Energy and Climate Change
- City Hall of Alaior
- City Hall of Es Castell
- City Hall of Ciutadella de Menorca
- City Hall of Ferreries
- City Hall of Maó
- City Hall of Es Mercadal
- City Hall of Es Migjorn Gran
- City Hall of Sant Lluís

LOCAL, NATIONAL AND INTERNATIONAL ENTITIES

- Economistas Frente a la Crisis Association
- Leader Illa de Menorca Association
- Ramón San Martín Association
- TECNICAT Association
- Climate Alliance
- Federació d'Associacions de Veïns de Menorca
- Fundación Renovables
- Balearic Group of Ornithology and Defence of Nature - GOB Menorca
- Menorcan Institute of Studies - OBSAM – Strategic Directives of Menorca
- Menorca Preservation Fund
- Plataforma por un Nuevo Modelo Energético

COMPANIES AND BUSINESS GROUPS

- AEDIVE - Asociación Empresarial para el Desarrollo e Impulso del Vehículo Eléctrico
- Menorca Airport - AENA
- ASEIME - Asociación de Empresas de Instalaciones Eléctricas y de Telecomunicaciones de Menorca
- Asociación Hotelera de Menorca – ASHOME
- Confederation of Business Associations of the Balearic Islands - CAEB Menorca
- ECOOO Revolución Solar
- Ecosis Ingeniería
- ENDESA
- Federació de la Petita i Mitjana Empresa de Menorca – PIME Menorca
- Fotoplat
- Global New Energy Finance - GNE Finance
- ARTIEM hotel group
- MIATEC Innova
- NISSAN
- Q-ENERGY
- Red Eléctrica de España
- SOM ENERGIA - Grup Local Menorca
- Unión Española Fotovoltaica (UNEF)

List of letters of support received as of February 2019.

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